(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 841 763 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
13.05.1998 Bulletin 1998/20

(51) Int Cl.[6]: **H04B 7/26**

(21) Application number: **97660109.6**

(22) Date of filing: **16.10.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **25.10.1996 FI 964308**
19.02.1997 US 802645

(71) Applicant: **NOKIA MOBILE PHONES LTD.**
02150 Espoo (FI)

(72) Inventors:
- **Rikkinen, Kari**
90650 Oulu (FI)
- **Rinne, Mikko J.**
00650 Helsinki (FI)
- **Ahmavaara, Kalle**
00330 Helsinki (FI)
- **Rinne, Mika**
02320 Espoo (FI)

(74) Representative: **Johansson, Folke Anders et al**
Nokia Mobile Phones Ltd.,
P.O. Box 100
00045 Nokia Group (FI)

(54) **Method for radio resource control**

(57) In order to control the use of physical radio resources, the physical radio resources are divided into chronologically consecutive frames (14), so that a frame contains slots (16, 17, 18) of various sizes, which slots represent a given share of the physical radio resources contained in the frame and can be individually allocated to different radio connections. The first dimension of a frame is time and the second dimension can be time, frequency or code. In the direction of the second dimension the slots represent various sizes, and a given first integral number of slots of the first size can be modularly replaced by another integral number of slots of another size. A certain number of consecutive frames form a superframe (19), in which case frames with corresponding locations in consecutive superframes are equal in slot division and allocations, if the data transmission demands do not change. Changes in the state of occupancy of the slots are possible at each superframe. In order to form an uplink connection, the mobile station sends a capacity request, where it indicates the type of requested connection and the demand of resources. In order to form a downlink connection, the base station subsystem sends a paging call, where it indicates the location in the superframe of the slots allocated to the connection. In order to indicate the state of occupancy, the base station subsystem maintains a superframe-size parametrized reservation table.

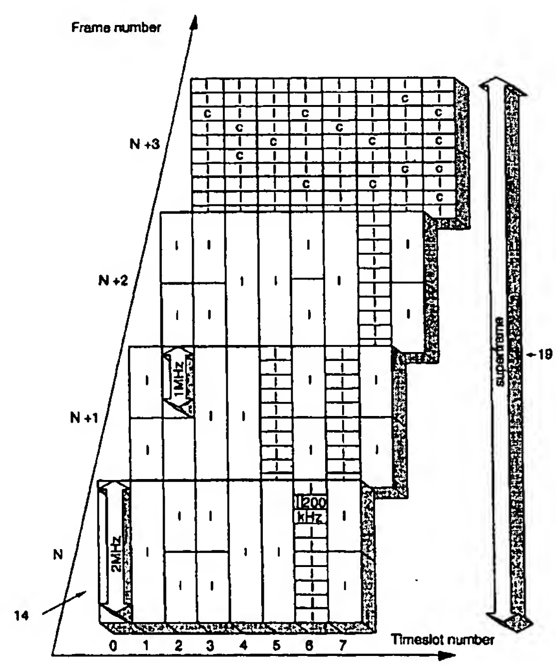


Fig.3

EP 0 841 763 A1

Description

TECHNOLOGICAL FIELD

The invention relates generally to sharing radio resources between various users in a cellular radio system. Particularly the invention relates to sharing radio resources in a system where the users' data transmission needs, both in quality and quantity, change rapidly.

BACKGROUND OF THE INVENTION

At the moment of filing this application, the most general form of mobile personal telecommunication is a second-generation digital cellular radio network; these networks include the European systems GSM (Global system for Mobile telecommunications) and its extension DCS1800 (Digital Communications System at 1800 MHz), the North American (USA) systems IS-136 (Interim Standard 136), IS-95 (Interim Standard 95) and the Japanese system PDC (Personal Digital Cellular). These systems transmit mainly speech, telefaxes and short text messages, as well as digital data at a limited speed, for instance files transmitted between computers. Several third-generation systems are being designed, the aims being world-wide coverage, a large selection of data transmission services and a flexible sharing of capacity, so that a given user may, when desired, transmit and/or receive even a large amount of data at a high speed.

The European Telecommunications Standards Institute ETSI has suggested a third-generation mobile telecommunications system called UMTS (Universal Mobile Telecommunications System). Its aim is a wide operating environment including homes, offices, urban and rural environments as well as stationary and mobile stations. The selection of services is large, and in addition to the currently known mobile telephones, the types of mobile stations include for instance multimedia terminals and multipurpose terminals that mediate telecommunications between the UMTS system and various local systems.

Figure 1 illustrates an exemplary cell 11 of the UMTS system, provided with a stationary base station subsystem 12 (BSS), within the range of which there exist or move, along with the users, several different mobile stations 13. The base station subsystem may comprise one or several base stations, as well as a base station controller controlling their operation. In between the base station subsystem and the mobile stations, there is a radio connection, for which a given radio frequency range is reserved, and the operation of which is regulated by the specifications of the system. The time and frequency range available for the radio connection together define so-called physical radio resources. One of the biggest challenges of the base station subsystem is to control the use of these physical radio resources so that all terminals located in the cell coverage are at any moment capable of receiving data transmission services of the requested quality, and that adjacent cells interfere with each other as little as possible.

From the prior art systems, there are known several methods for sharing radio resources. In time division multiple access (TDMA), each of the employed transmission and reception frequency bands is divided into time slots, among which the base station subsystem allocates one or several cyclically repeated time slots to the use of a given terminal. In frequency division multiple access (FDMA), the utilised frequency range is divided into very narrow bands, among which the base station subsystem allocates one or several to each terminal. Many current systems apply a combination of these, where each narrow frequency band is further divided into time slots. In coded division multiple access (CDMA), each connection between the mobile station and the base station subsystem obtains a spreading code, whereby the transmitted information is spread randomly within a fairly large frequency range. The codes used within the cell coverage are mutually orthogonal or nearly orthogonal, in which case a receiver that recognises the code may distinguish the desired signal and attenuate other simultaneous signals. In orthogonal frequency division multiplex (OFDM), suited mainly for broadcasting-type services, data is transmitted from the transmitting central station on a wide frequency band, which is divided into equidistant sub-frequencies, and the simultaneous phase shifts of these sub-frequencies create a two-dimensional bit flow in the time-frequency space.

As for the technology of packet switched radio networks, there are also known various packet-based connection protocols, where the connection between the mobile station and the base station subsystemis not continuous but proceeds in packages with pauses of varying durations in between. Compared with continuous connection systems, i.e. with so-called circuit-switched networks, there is achieved the advantage that the radio resources required by a given connection are not unnecessarily occupied when there is a temporary pause in the connection. A drawback is generally a longer data transmission delay, because after each pause, the transmission of a new packet requires the exchange of certain control or signalling messages between the mobile station and the base station. Delays can also be caused by different routing of the packages between transmitter and receiver.

It is typical of third-generation cellular radio networks that for instance in the case of Figure 1, with some of the terminals 13 it suffices to have a fairly low-capacity radio connection with the base station, but some of them need, at least temporarily, a remarkably larger share of the common radio resources than the others. Low-capacity connections can be for example speech connections, and a high-capacity connection can be for example the loading of an image file in a data network connection via the base station subsystem to the mobile sta-

tion, or a video image connection during a videophone call. In the prior art, there is not known a method where the base station subsystem could divide the available radio resources in a flexible and dynamic way between the various users. Some related prior art methods are discussed in the following.

US Patent No.5 533 044 discloses a frame structure where the size of each time slot is the same. Different amounts of data may be transferred in each time slot by choosing the modulation method according to need.

The article "TDMA Based Adaptive Modulation with Dynamic Channel Assignment (AMDCA) for Large Capacity Voice Transmission in Microcellular Systems" by T. Ikeda et al in Electronics Letters, vol. 32, no. 13, 20 June 1996, pages 1175 - 1176, discloses another frame structure with a multiple of equally sized slots. Each connection has the same data rate, but different modulation methods are employed to compensate for the varying connection quality. A troubled connection is given more slots than the connections with better quality, so that the troubled connetion may employ a more robust modulation scheme.

Patent document No. GB 2 174 571 discloses a frame structure that may accommodate a varying number of time slots. Each connection has the same data rate, but different modulation schemes are again used to provide robustness against noise and interference. The length of each time slot in a frame depends on the modulation method used in the connection to which the time slot has been allocated.

Patent document No. EP 633 671 describes a method for multiplexing the acknowledgement messages used in a packet switched radio communication system. Instead of letting every mobile station transmit its acknowledgement messages freely in a Random Access (RA) slot the system divides the RA slot into subslots by cutting it into shorter time intervals or allocating orthogonal codes for the duration of the RA slot. Only one mobile station or a small group of mobile stations is allowed to transmit in each subslot to reduce the risk of acknowledgement messages colliding with each other.

OBJECT OF THE INVENTION

An object of the present invention is to introduce a method for a flexible and dynamic division of radio resources in the base station subsystem of a cellular radio network.

SUMMARY OF THE INVENTION

The object of the invention is achieved by dividing the radio resources in the base station subsystem - or in a similar arrangement responsible for the division of radio resources - into frames, among which the base station subsystem can allocate, according to the traffic demands of the moment, various sizes of modular, parametrized sections to be used by the different connections. These frames are repeated cyclically so that the repetition sequence contains either a single frame or a group of consecutive frames.

The invention is characterised in what is said in the characterizing portions of claims 1,22, 31, 37, 42 and 46.

In the method of the invention, the so-called physical layer of the transmission channel between a first radio station and a second radio station is divided into frames. The exemplary denominations "base station" and "mobile station" are used to distinguish the radio stations from each other throughout this patent application. Each frame may be further divided into smaller units, the size of which is defined by two coordinates or dimensions, which makes the subdivision of a frame conceptually two-dimensional in structure. The first dimension is time; this means that the frame has a given duration in time, which can be further divided into consecutive time slots. In a preferred embodiment of the invention, each frame contains an equal number of time slots, but the usage of the time slots may vary from one frame to another. The second dimension can be time, frequency or code. If also the second dimension is time, each time slot of the frame is further divided into smaller sub-time slots. If the second dimension is frequency, there can be extracted, in each time slot contained by the frame, frequency bands that are narrower than the total allocated frequency band covered by the frame. If the third dimension is code, a given number of mutually orthogonal or nearly orthogonal codes is available during each time slot.

The smallest resource unit to be allocated from one frame is a slot, the size of which is in the first dimension defined by the length of the time slot and in the second dimension by a division unit determined according to the nature of the second dimension. For instance in a time-frequency frame, the size of the slot in the second dimension is the bandwidth of the frequency band employed in each case. One slot is always allocated as a whole to the use of one connection. It is important to notice that in this patent application, a time slot is conceptually a different thing that a slot. A time slot is generally a division unit of a frame in the time dimension. A slot is the unit of physical radio resources that may be allocated to a single connection.

A certain predetermined number of consecutive frames forms the so-called superframe. Because in digital systems various numbers in general are most naturally powers of two, the superframe advantageously contains 1, 2, 4, 8, 16, 32 or 64 frames. The flexibility and dynamic adaptability of the method according to the invention are both due the fact that the slots contained by a given frame are not necessary equal in size, that the slot structure of the frames contained in the superframe is not necessarily similar, and that it is not necessary to allocate an equal number of slots from a frame or superframe to each connection. The slot structure and the reservation of slots for the use of various connections can change superframe by superframe. On the

other hand, if the data transmission need does not change, the first frame in a given superframe has a similar slot structure as the first frame of the preceding superframe, the second frame is similar to the second frame of the preceding superframe, and so forth. The word superframe is naturally only an exemplary denomination to a concept that may represent one or more consecutive frames.

In an uplink data transmission, i.e transmission that proceeds from the mobile stations to the base station subsystem, the mobile stations need some kind of arrangement by which they can reserve data transmission capacity for use. In a preferred embodiment of the invention, each uplink superframe contains random access slots, during which the mobile stations can freely send packet-shaped capacity requests. Respectively, downlink superframes contain allocation grant slots, where the base station subsystem notifies the granted allocations. Granting takes place on the basis of capacity requests received successfully by the base station subsystem and according to the priority regulations set for different types of connections and the prevailing traffic load. The base station subsystem advantageously maintains a superframe-size reservation table, where it manages the allocations so that the available radio resources are utilised in an optimal fashion.

In a downlink data transmission the base station subsystem allocates data transmission capacity similarly according to the priority regulations set for different types of connections and the prevailing traffic load. It notifies the downlink allocations preferably in the same paging messages that it uses to inform the mobile stations about incoming downlink transmission requests. Once a mobile station has acknowledged the correct reception of a paging message, the downlink transmission may begin using the allocated transmission capacity.

BRIEF DESCRIPTION OF DRAWINGS

The invention is described in more detail below, with reference to the preferred embodiments presented as examples and to the appended drawings, where

Figure 1 illustrates a known cell in a cellular system,
Figure 2a illustrates some structural elements of a frame according to the invention,
Figure 2b illustrates a variation of Figure 2b,
Figure 3 illustrates a superframe according to a preferred embodiment of the invention,
Figure 4a illustrates an uplink realtime data transmission according to a preferred embodiment of the invention,
Figure 4b illustrates a timing aspect of the messages of Figure 4a,
Figure 5a illustrates a downlink realtime data transmission according to a preferred embodiment of the invention,
Figure 5b illustrates a timing aspect of the messages of Figure 5a,
Figure 6a illustrates an uplink non-realtime data transmission according to a preferred embodiment of the invention,
Figure 6b illustrates a timing aspect of the messages of Figure 6a,
Figure 7a illustrates a downlink non-realtime data transmission according to a preferred embodiment of the invention, and
Figure 7b illustrates a timing aspect of the messages of Figure 7a,
Figure 8 illustrates a timing aspect of messages in asymmetric trasmission resource sharing according to a preferred embodiment of the invention,
Figure 9 illustrates full TDD operation according to the invention,
Figure 10 illustrates a method according to the invention for regulating the transmission power, and
Figure 11 illustrates an advantageous algorithm for slot allocation.
Figure 12a shows a block diagram of a base station subsystem according to the invention, and
Figure 12b shows a block diagram of a mobile station according to the invention.

Figure 1 was already referred to above, in the description of the prior art; therefore we shall mainly refer to Figures 2a - 11 in the description of the invention and its preferred embodiments below. Like numbers for like parts are used in the drawings.

DISCUSSION OF PREFERRED EMBODIMENTS

Figure 2a illustrates a two-dimensional frame 14 according to a preferred embodiment of the invention. In the above description it was maintained that the first dimension of the frame is time and the second dimension can be either time, frequency or code. In the case of Figure 2a, the second dimension of the frame 14 is frequency or time. The size of the frame in the direction of both dimensions must be chosen so that it is compatible with other specifications set for the system. In this example, the length of the frame in the time direction is about 4.615 milliseconds, and it is divided, in the time direction, into eight time slots, in which case the length of one time slot 15 is about 0.577 ms. The frame width in the frequency direction is about 2 MHz.

The smallest uniform structural elements of the frame, i.e. the slots, are various subdivisions of a time slot 15. In the lower left portion of Figure 2a, time-frequency division is applied, whereby the chronological length of each slot is the same as that of a time slot, but its width in the frequency direction may be 200 kHz, 1 MHz or 2 MHz. Reference number 16 denotes a large,

0.577 ms x 2 MHz slot, reference number 17 denotes a medium-sized, 0.577 ms x 1 MHz slot, and reference number 18 denotes a small, 0.577 ms x 200 kHz slot. In the lower right portion of the Figure, time-time division is applied, whereby each slot employs the whole 2 MHz bandwidth of the system but its chronological duration may be 1/1, 1/2, or 1/10 of the length of a time slot. Reference number 16 denotes again a large, 0.577 ms x 2 MHz slot, reference number 17 denotes a medium-sized, 0.2885 ms x 2 MHz slot and reference number 18 denotes a small, 0.0577 ms x 2 MHz slot. In those divisions in which five small slots share a time slot with one medium-sized slot (row C: of the division examples), it is naturally possible to present a mirror image alternative (for example a time slot which begins with a medium-sized slot and ends with five small slots).
According to another suggestion, the number of different slot size categories is four, and their relative sizes are such that the slot of the largest size category would correspond to two slots of the second largest size category, four slots of the third largest size category and eight slots of the smallest size category. Also other arrangements for the relative slot sizes are possible.

A carrier wave solution, where one frame can contain several elements with different widths on the frequency band, is called a parallel multicarrier structure. The base station subsystem may change the frame structure, so that it replaces one large slot by two medium-sized, ten small or one medium-sized plus five small slots or vice versa, or so that it replaces one medium-sized slot by five small slots or vice versa. This property is called the modularity of the frame: a given slot or slot group forms a module (like the group of five small slots 18 on row C: of the division examples), which can in the corresponding time slot contained in some later frame be replaced by a different module (like a single medium-sized slot 17 on row B: of the division examples), so that the rest of the contents of the frame are not changed, and the available bandwidth is always optimally utilised. The invention does not as such limit neither the number of time slots contained in the frame nor the widths of allowed carrier bands, but in order to maintain modularity, it is particularly advantageous that the slots are each other's integral multiples with respect to their dimensions. For instance three 250 kHz wide slots in time-frequency division could not be modularly replaced by 450 kHz wide slots, but only one 450 kHz slot would fit in the space left by the three narrower slots, and 300 kHz of the bandwidth would remain unused.

The invention does not require that the frame would occupy a continuous range of frequencies (2 MHz in Figure 2a). It is possible to define a frame so that it covers two or more separate frequency bands. Even a single slot may cover two or more separate frequency bands, which naturally requires the corresponding transceiver to have multiple operation capabilities, i.e. in reception the capability of receiving on at least two different reception frequency bands simultaneously and combining the received information correctly, and in transmission the capability of dividing information into at least two separate transmitter branches and transmitting it simultaneously on at least two different transmission frequency bands.

Figure 2b illustrates a CDMA alternative to the division of time slots according to Figure 2a. During each time slot 15 there may be a different number of allowed spreading codes, with different spreading ratios. The spreading ratio is a characteristic feature of a spreading code and from the viewpoint of resource sharing it defines how much physical radio resources must be allocated to a single connection. The bigger the spreading ratio of a spreading code used in a connection, the lower the bit rate in that connection, and correspondigly the larger the number of possible simultaneous connections during a given period of time using a given bandwidth. In the example of Figure 2b, three types of spreading codes are available. The Code 1 type spreading codes have such a small spreading ratio R that information that is transmitted with a Code 1 type spreading code fills the capacity of a whole time slot (row A:). The spreading ratio of Code 2 type spreading codes is 2*R (i.e. twice that of Code 1), so two connections using orthogonal or nearly orthogonal Code 2 type spreading codes may exist simultaneously in a single time slot (row B:). The Code 3 type spreading codes have a spreading ratio 10*R (i.e. ten times that of Code 1), so different combinations of orthogonal or nearly orthogonal spreading codes may exist simultaneously; on row C: the time slot accommodates five connections with Code 3 type sreading codes and one with a Code 2 type spreading code, and on row D: there are ten simultaneous connections with Code 3 type spreading codes. A simple comparison between Figures 2a and 2b shows that the time-code division may be interpreted to define slots in a fashion that is analogous to the use of time-frequency or time-time-division.

Apart from the slot dimensions, the capacity of a slot, i.e. the amount of data that can be transmitted in one slot, depends on the modulation and error protection methods used in the coding of the data, as well as of the rest of the signal structure in the slot. In the time-frequency arrangement according to Figure 2a, where the allowed bandwidths are 200 kHz, I MHz and 2 MHz, it has been found advantageous to use, on the two narrower bandwidths (200 kHz and 1 MHz) a binary-offset QAM (B-O-QAM, Binary Offset Quadrature Amplitude Modulation) and on the widest bandwidth (2 MHz) a quaternary offset QAM (Q-O-QAM, Quaternary Offset Quadrature Amplitude Modulation). Other modulation methods are also possible; they are as such known to the person skilled in the art.

Figure 3 illustrates a superframe according to a preferred embodiment of the invention. It was already pointed out that the invention does not limit the number of consecutive frames contained in the superframe, but advantageous numbers are powers of two. At its short-

est, a superframe may consist of only one frame. In the case of Figure 3, the superframe 19 contains four chronologically consecutive frames 14. Here the frames have consecutive numbers, so that the number of the first frame is described by letter N representing a non-negative integral, the next frame is N + 1, the next N + 2 and the number of the last frame in the superframe is N + 3. The time slots of the frames are also numbered with consecutive non-negative integrals, so that the first time slot in each frame is number 0, and the last time slot is number 7. The drawing also illustrates, by way of example, the division of the slots into payload slots and control data slots. Slots containing payload information, i.e. transmittable data proper, are marked with letter I (Information), and the slots containing control data, i.e. signalling data, are marked with letter C (Control).

The control data slots form one or several logic control channels, which are available for instance for transmitting messages controlling the starting, maintaining or ending of a connection, for defining the need to change base stations and for exchanging commands and measurements relating to the transmission power and the power-saving mode of the mobile stations between the base station subsystemand the mobile stations. It is advantageous to place the control slots in a certain relatively compact portion of each frame which contains control slots, because this way the rest of the frame may be very flexibly allocated in different modular slot combinations. If the control slots would be scattered all over the frame structure, only a limited selection of allocatable slots would fit between them.

According to the preferred embodiment of the invention, the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) maintains a parametrized reservation table, which indicates the size and state of occupancy of each slot, as well as other possible parameters concerning the slot. Changes in the slot structure of the frames 14 and/or in the allocation of slots for the use of given connections take place in between the superframes, i.e. the reservation table remains valid for the duration of one superframe at a time. In order to ensure an optimal operation, the base station subsystem must have a reservation table routine, which maintains the reservation table according to given evaluation criteria. Among such important criteria that the reservation table routine takes into consideration before granting access to a new connection are for instance the traffic load, the type of information contained in the new connection (for example speech, video, data), the priority defined on the basis of the new connection (for example ordinary call, emergency call), the general power level of the traffic load as well as the type of the data transmission connection (for example realtime, non-realtime). Moreover, it is possible to define more sophisticated criteria, such as the susceptibility to interference of a given slot, and the transmission power required by the slot.
If a certain base station takes into consideration the reservation tables of the surrounding base stations, too, it may in its own reservation table allocate the slots according to the power level and switching type of the connection. The former means that mobile stations applying a high power level and a low power level have their own allocated slots, which are located in the reservation tables of adjacent base stations, in optimal locations with respect to the total interference of the system. The latter means that circuit-switched and packet-switched connections have their own slots located in the reservation tables of adjacent base stations in optimal locations with respect to the total interference of the system. Optimality is defined so that all users suffer as little as possible from the noise signals of other users. If the slots are allocated for instance according to the power level, the first base station grants low-power users (those located near the first base station) such slots, during which in the second base station there is a connection of a high-power user (one located far from the second base station).

Previously known slot allocation methods are usually sequential (of 8 available slots, for example slot number 0 is allocated first, then slot 1 and so on; or slot number 0 is allocated first, then slots 2. 4, and 6 in this order, then slots 1, 3, 5, and 7) or random. In connection with the present invention it has been found advantageous to use a slot allocation method that takes into consideration the different evaluation parameters that may be presented to describe each slot. The base station subsystem may measure the level of noise in each slot and arrange the free and allocatable slots according to their quality, i.e. noise level. If a new slot request indicates that the desired new connection should have very tight realtime requirements with only limited retransmission possibilities, the base station subsystem will give it a very high-quality slot with low noise levels. A non-realtime connection with good retransmission tolerance could get a lower-quality slot, in order to keep the best slots free for possible future realtime connection requests. The size of a slot is important: if there are both small and large slots free and available in a frame, and a new slot request indicates only a small need of resources, it is advisable to allocate an existing small slot for it even if it could get a better quality slot through replacement of a larger slot with a group of smaller slots in a modular fashion and allocation of one of those.

The representation of the slot allocation method in the base station subsystem may be an allocation equation or a logical algorithm (conclusion chain). The former means that the base station gives different calculational weights to the relevant factors in consideration (noise level, realtime service requirements, need for splitting of large slots, estimated power level, etc.) and calculates a result that points at a certain slot. The latter means that the base station subsystem maintains a set of candidate slots and evaluates them one at a time to find out which one would suit best to the newly requested connection.
Figure 11 illustrates an exemplary logical algorithm that

the base station subsystem may use to determine, which slot it will allocate to a given new connection. Operation begins with a slot request 100 which may come either from the network side (downlink slot request) or from the mobile station's side (uplink slot request). In block 101 the base station subsystem checks, which frame storage (uplink or downlink) it should choose. The actual selection of a storage (reservation table) is done as a background process in blocks 102, 103, and 104, and the algorithm proceeds to block 106. Here a frame selection process 107, 108, 109 similar to the frame storage selection is initiated. In the Figure we suppose that each superframe consists of two frames.

In block 110 the base station subsystem starts the evaluation process from the time slot that has the lowest fragmentation value, i.e. that contains the largest slots. In block 111 it rejects all timeslots where the new connection would result in multicarrier allocation. In block 112 it checks, whether there are any other factors that would prevent the use of the time slot (too small slot capacity, preset transmission power limitations, unacceptably high noise levels etc.) and if not, it updates the set of candidate time slots. Block 114 causes a repetition of steps 110, 111, 112, 113, and potentially 105 until all timeslots have been scanned. In block 115 the base station finds the best candidate time slot by applying certain radio resource management rules and selection criteria. There may be for example two best candidates with equally low interference, and the base station subsystem must examine, whether the estimated power requirement for the new connection agrees with certain preset power and noise limitations in each slot and whether choosing of any of the best candidates would imply calculational penalty in the form or splitting a large slot into smaller ones.

After having made the selection in block 115, the base station subsystem additionally checks in block 116, whether the calculated quality estimates 117 indicate a sufficiently high transmission quality. Normally the procedure continues to block 118, but it may happen that evan the best candidate slot will not offer enough quality. In such cases the base station subsystem branches into block 119, where it initiates a possible operation mode change to enhance the transmission quality. The procedure ends in a slot assignment decision 120.

In the method according to the invention, the sharing of radio resources takes place in similar fashion both as regards realtime and non-realtime services: the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) allocates slots for each service according to their needs. Similar control messages and mechanisms regulate the distribution of radio resources in both cases; only the detailed content of the control messages and some principles of allocation and deallocation are somewhat different depending on the type of service in question. Data transmission over radio path during an already created connection is somewhat different depending on whether the service in question is realtime or non-realtime. Applications requiring realtime or nearly realtime service are for instance speech transmission in packets and the video connection required by a videophone. In a simulation of the method according to the invention it was presupposed that in the transmission of speech, in between the base station subsystemand the mobile station there is achieved a bit error ratio (BER) 10^{-3}, when the longest allowed data transmission delay is 30 ms. In a video connection required by a videophone, the corresponding values are 10^{-6} and 100 ms, where the longer delay is caused by the time interleaving of the transmitted data. These services apply a forward error correction (FEC) type error correction and a radio resource reservation protocol to be explained in more detail below. A non-realtime service is for instance file transmission in an ordinary Internet connection. It applies packet-type data transmission and an ARQ-type error correction protocol (automatic repeat on request).

We shall next observe realtime uplink data transmission in an ordinary case, with reference to Figures 4a and 4b. The arrows of the Figure 4a represent data transmission between a base station (BS) and a mobile station (MS) in chronological order so that time in the drawing passes from top to bottom. Certain superframes transmitted by the base station contain so-called Y slots, where the base station notifies when in the uplink direction there are next found PRA (packet random access) slots, i.e. such points in the uplink superframe where the mobile stations can send capacity requests. Arrow 20 represents the data transmitted in an Y slot of a given downlink superframe concerning the location of the next PRA slots. If the PRA slots would have a constant location in each uplink frame or superframe, the base station would not need to announce their location in an Y slot, but it adds flexibility to the system to reserve the base station subsystem the possibility of placing the PRA slots in the most suitable way and to change their location between superframes.

In one of the successive PRA slots the mobile station transmits, according to arrow 21, a PRA message where it identifies itself and informs what type of connection is requested (realtime, coding, slot type etc. factors). Because there is no coordination whatsoever between different mobile stations, it may happen that several mobile stations transmit a PRA message simultaneously.

In that case one at the most is received. However, in Figure 4a it is assumed that the PRA message according to arrow 21 is received, in which case in the PAG (packet access grant) slot of the next downlink frame the base station notifies, according to arrow 22, that a given uplink slot or slots are granted for the mobile station. At the same time it informs the location of the granted slot (slots) in the uplink superframe. In the packet access protocols of the prior art the requesting station generally obtains as its radio resource that time slot or

other corresponding resource slot where it transmitted a successful capacity request. According to the present invention, the slot (or slots) allocated to the connection can be located anywhere within the scope of the next uplink superframes.

When the mobile station has received information of the granted radio resources, it starts data transmission according to arrow 23. During the connection there may arise a situation where the mobile station wants to increase the amount of radio resources it has available. In that case it reserves further slots according to arrow 24, by means of the same procedure that was explained above, i.e. by transmitting a capacity request where it indicates what size and type the new slot should be. It may also happen that during the connection, the data transmission demand of the mobile station decreases, and it wishes to reduce the employed radio resources. Now it ends transmission in given slots according to arrow 25, in which case the base station can allocate the released slots to the use of other connections. Arrow 26 represents a message whereby the mobile station ends transmission.

Figure 4b serves to clarify the relation of some the above-mentioned messages to the frame and superframe timing. Here we assume that there are two frames 14 in each superframe 19. We further assume that the downlink (DL) direction transmission occurs simultaneously with the corresponding uplink (UL) direction transmission, the two being separated from each other through for example Frequency Division Duplexing (FDD), i.e. placing them on different frequency bands. Still further, we assume that in the middle of each frame 14 there is a range of control slots that appear shaded in Figure 4b. It is advantageous to place the control slot ranges coincidentally in time in both downlink and uplink directions, because it will prevent the loss of important control information due to simultaneous traffic transmission. Taken the other way raound, it will also prevent the loss of any traffic transmission opportunities due to control information reading. The chronological order of the frames in Figure 4b is from left to right.

The mobile station listens to the downlink transmission DL and finds the slot addresses of the next available PRA slots in a message that the base station transmits in a Y slot. These available PRA slots are situated in the second frame of the leftmost superframe in Figure 4b. The dashed line represents a logical connection between the slots, in other words it shows that in the Figure the message sent in a certain Y slot governs the use of the PRA slots in the following complete UL frame. The mobile station uses a PRA slot to transmit a PRA message to the base station. Taken that the attempt is succesful, the base station transmits a PAG message in a PAG slot of the next complete DL frame. The PAG message tells the mobile station to use a certain slot (or certain slots) RT from the next complete UL frame for the desired transmission carrying real time traffic. The dashed lines from the PAG slot to the next complete UL frame show that the granted UL slot may be anywhere in the frame. The transmission continues in the same slot until the data source is exhausted or the base stations sends a separate *RT uplink channel update* command (not shown in Figure 4b).

A downlink realtime data transmission takes place according to Figures 5a and 5b. A separate slot capacity request is not needed, because the base station subsystem itself maintains the reservation table for the slots and is thus able to direct downlink data transmission to a suitable slot. The message that tells the location of the chosen slot(s) to the mobile station can be transmitted to the mobile station through packet paging (PP) channels, at least one of which is read by each active mobile station. The repetition of the PP message in the packet paging channel, illustrated by arrows 27 and 28, means that the base station transmits a PP message until the mobile station answers (or until a given time limit is surpassed). The mobile station that has received the transmitted PP message echoes, according to arrow 29, the PP message back to the base station as a packet paging acknowledgement (PPA). The base station starts transmission 30 after receiving, intermediated by the PPA, confirmation that the call was received. The resource demands of downlink data transmission can also change during the connection, in which case the base station subsystem allocates more slots to the connection (when resource demand grows) 31 or releases part of the slots (when resource demand decreases) 32. Notification of the changes is transmitted to the mobile station advantageously through packet paging. Arrow 33 illustrates the ending of the transmission.

Figure 5b clarifies the relation of PP and PPA messages and downlink realtime data transmissions to the frame and superframe timing in an embodiment where we again assume simultaneous FDD uplink and downlink transmission with two frames 14 per superframe 19. After the base station has transmitted a PP message, the first acknowledging chance for the mobile station is in the PPA slots of the next complete UL frame. After receiving the PPA acknowledgement message the base station may start the realtime DL data transmission in the next complete DL frame. It continues the realtime DL data transmission in the same slot in each following DL superframe, until the data source becomes exhausted (exhaustion not illustrated in the Figure), which the mobile station detects when it finds that the slot is empty.

Several simultaneous connections requiring realtime service may exist, in between a given mobile station and base station, both in the uplink and downlink direction. Simultaneous connections are also called parallel connections. According to a preferred embodiment, the mobile station has a given temporary logic identifier which distinguishes it among other mobile stations communicating with the same base station subsystem. The length of this identifier can be for instance 12 bits. In order to distinguish between parallel connections, there may be used a short (for instance 2-bit) additional iden-

tifier. When the mobile station wishes, during a given connection, to start a parallel realtime connection, it sends the base station subsystem a capacity request where it notifies its temporary logic identifier as well as its additional identifier with a value different than the value of the additional identifier describing the preceding ongoing realtime connection. Respectively, the base station subsystem may start a new downlink parallel, realtime connection by transmitting a PP message where it includes the logic identifier of the mobile station for which the message is intended, plus an additional identifier with a value different than the values of additional identifiers describing already ongoing realtime connections. On the basis of the additional identifier, each receiving station knows whether the transmitting station wishes to increase the capacity of some ongoing realtime connection or to start a new parallel connection.

Figures 6a and 6b illustrate a non-realtime uplink data transmission in a normal case. Arrow 34 corresponds to arrow 20 in Figure 4a, i.e. it represents the data concerning the location of the next PRA slots transmitted in the Y slot of a given downlink superframe. In one of the successive PRA slots, the mobile station transmits, according to arrow 35, a PRA message where it identifies itself and notifies how much non-realtime data it wishes to transmit. The amount of data can be given for instance in bytes. In the next PAG slot, the base station notifies, according to arrow 36, what is the location of the control slot reserved as the uplink-direction control channel in the downlink superframe. In the next control slot, the base station transmits, according to arrow 37, the locations in the uplink superframe of the first slots reserved for the connection. In these slots, the mobile station transmits uplink data according to arrow 38. The uplink slots are grouped for instance so that 16 slots form a group. A control message according to arrow 37 has transmitted for the mobile station information of the location of these 16 slots. When the mobile station has transmitted 16 slotted messages, it receives, according to arrow 39, in the next control slot from the base station subsystem a response, where the base station informs how the data was received in the slots of the first group. If the base station has found fault in some slots, the mobile station must retransmit the data contained in these slots. The control message illustrated by arrow 39 also contains information of the location of the slots belonging to the next group, in which case uplink transmission continues in these slots according to arrow 40. Transmission ends when the mobile station has transmitted all of the desired information.

In the above cases, the realtime service of Figure 4a, and in the non-realtime service of Figure 6a, the interpretation of the reservation message is different. In the realtime service, there is reserved a given radio resource (slot) for continuous use from consecutive superframes. This means the same as the reservation of a given transmission rate (x bits/s) for the use of the connection. In the case of a non-realtime service, the resources are reserved for the transmission of a given amount of bits or bytes, in which case the data transmission rate need not be constant. If there are a lot of radio resources available, the base station subsystem may, in the control messages represented by arrows 37 and 39, grant for the mobile station slots that are very near to each other. If the rest of the traffic load of the base station is heavy, or if it grows during the non-realtime connection, each superframe contains less free slots, and the control messages described by arrows 37 and 39 grant for the mobile station slots that are located further away from each other in the data flow.

Figure 6b illustrates the timing in the setup phase of a non-realtime uplink connection. The graphical conventions are the same as in Figures 4b and 5b. The operation begins when the mobile station finds the slot address of the next available PRA slot(s) in a message that was transmitted in a Y slot from the base station. The mobile station sends a PRA message, which is here supposed to reach the base station at the first attempt. In the next complete downlink frame containing PAG slot (s) the base station sends a PAG message that identifies an NRT control slot (NC) from the following superframe. In the first NC slot the base station transmits a message in which it gives an address for a downlink ARQ slot as well as the addresses for the first granted uplink NRT traffic slots. The first one(s) of the granted uplink NRT traffic slots may be in the next complete uplink frame at earliest. The mobile station starts transmission in the allocated NRT traffic slots and the base station acknowledges the transmissions with ARQ messages and grants further uplink NRT traffic slots in the following NC slots. This continues until the total amount of uplink NRT data has been sent.

A downlink non-realtime data transmission differs from what was explained above and is illustrated in Figures 7a and 7b. When the base station subsystem wishes to transmit non-realtime data for the mobile station, it first transmits, according to arrow 41, a PP message containing information of the location of the slot or slots reserved to an uplink acknowledgement channel in uplink superframes, as well as of the location of the first slots reserved for the data to be transmitted in the downlink superframes. Arrow 42 illustrates the retransmission of the same PP message. When the mobile station notifies in a PPA message according to arrow 43 that it is ready for reception, the base station subsystem transmits the data in the previously informed slots according to arrow 44. The mobile station sends a positive or negative ARQ response 45 of the received data, which response may also contain measuring results used for downlink power regulation or similar information. If the location or amount of the downlink slots is changed, the base station subsystem notifies the mobile station to that effect, according to arrow 46. The transmission ends when the base station subsystem has transmitted all of the desired data and received a positive response. Naturally the transmission may end prematurely, if inter-

ference cuts the connection or the mobile station moves to an area covered by some other base station.

In Figure 7b the downlink non-realtime transmission starts with a PP message sent by the base station in a PP slot of a certain downlink frame. The mobile station responds by sending, in a PPA slot identified in the PP message, a PPA message and optionally an empty ARQ message in the corresponding slot that was also identified in the PP message. The first downlink transmission will occur at earliest in the next complete downlink frame following the frame during which the base station received the mobile station's PPA message. The mobile station acknowledges the downlink NRT transmission in its ARQ replies and the process continues until the non-realtime downlink data source has been exhausted (not shown in the Figure).

In non-realtime connections there can be applied the same principle of parallel connections that was explained above, in the description of realtime services. However, because the radio resource control method according to the invention aims at a situation where up to all otherwise free slots can be temporarily allocated to a given non-realtime connection, the concept of parallel connections is not as important for non-realtime services as it is for realtime services. In the case of non-realtime services, a non-realtime data transmission task can generally be finished before starting the next.

The invention does not require that the radio transmission capacities in uplink and downlink transmission should be equal as suggested by the graphical layout of Figures 4b, 5b, 6b and 7b. On the contrary, the invention allows the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) to allocate slots from the uplink frames for downlink traffic or vice versa. For example in teleshopping, electronic newspaper services and WWW (World Wide Web) browsing the need for downlink capacity is far greater that the need for uplink capacity, which could result in unbalanced resource usage if the system capacities in uplink and downlink could not be made asymmetrical dynamically.

When the slot allocation routine has decided to allocate an uplink slot to downlink traffic the base station subsystem simply tells the mobile station in a PP message that the slot it should receive is in uplink domain (for example, on uplink frequency) instead of the usual downlink. In the opposite situation, in which a downlink slot is allocated for uplink transmission, a PAG message (in realtime services) or an NC message (in non-realtime services) from the base station subsystem allows the mobile station to use a certain nominally downlink slot or slots for its uplink transmission. It has to be noted, however, that changing the transmission direction in the middle of a superframe requires a guard interval in between, the length of which is equal to two times the maximum propagation delay in the cell. It is therefore advisable to group the slots into compact blocks that contain only slots in one and the same transmission direction, in order not to waste time in multiple consecutive transmission direction changes. If the coverage area of a certain base station is so small that the length of the guard interval is negligible, this restriction may be somewhat relieved.

Figure 8 illustrates the exchange of transmissions on the downlink frequency band DL and uplink frequency band UL when some uplink transmission capacity is reserved for realtime downlink use. The graphical conventions are the same as in Figures 4b, 5b, 6b and 7b, except that an additional crossed hatch now denotes a portion of the frames received for downlink use and an inclined hatch denotes a portion of the frames received for uplink use. During the first superframe period the base station transmits in a Y slot Y1 a message that tells the mobile station the location of PRA slots PRA1 in the next complete uplink frame. The mobile station uses the PRA opportunity to transmit a PRA message that reaches the base station and results in a PAG message PAG1 in the next complete downlink frame. The PAG message allocates a slot T1UL (or a group of slots) to the mobile station. From that moment on until the exhaustion of the uplink realtime data source (not shown in the Figure) the mobile station uses this allocation regularly in each superframe to transmit its realtime data.

In the second frame of the second superframe the base station transmits a PP message PP2 indicating its willingness to transmit realtime downlink data to the mobile station. The PP message PP2 identifies a slot (or a group of slots) T2DL from the second frame in each following uplink superframe. The mobile station transmits its PPA answer PPA2 in the next complete uplink frame, after which the base station starts using the identified (cross-hatched) portion T2DL of the uplink superframes for a downlink realtime transmission. The uplink frequency band UL is now effectively time-division duplexed (TDD). When the downlink transmission using the slot T2DL ends (not shown in the Figure), the uplink frequency band may return to a purely uplink state or the base station subsystem may allocate uplink capacity to another downlink transmission. Naturally there may be a multitude of simultaneous uplink and downlink connections in use, in the setup phase, or in the teardown phase, but for graphical clarity these are not shown in the Figures.

Next we shall consider some further duplexing aspects. One alternative is to arrange the uplink and downlink transmission in each cell according to time division duplex (TDD). In that case the transmission is not chronologically continuous in either of the directions, but transmissions in the two directions alternate on a frame basis during each superframe. Only one frequency band, common for both the uplink and downlink directions, is needed in the cell. If the users use a radio connection controlled according to the method of the present invention for browsing the www (World Wide Web) or for another similar purpose, where the data transmission need in one direction is manifold com-

pared to the other direction [illegible]ww-browsing the volume of the downlink data transmission is 7 - 15 times the volume of the uplink data transmission), the time division duplex can be arranged so that in each superframe, X consecutive downlink frames are followed by Y consecutive uplink frames (or Y consecutive uplink frames are followed by X consecutive downlink frames), where the relation of the integrals X and Y is X > Y. Still further, the cross-allocation scheme explained previously may be introduced so that even if there is a predetermined (fixed or dynamically changing) number of frames for each transmission direction, the base station subsystem may allocate downlink slots for uplink transmissions or vice versa.

Figure 9 illustrates the exchange of transmissions in fully time-division duplexed operation with all four possible combinations of uplink, downlink, realtime and non-realtime. Each row in the Figure represents a single frequency band that is used (here: symmetrically) for both uplink and downlink transmission. A superframe 19 consists of two frames 14, the first of which is for downlink (DL) and the second is uplink (UL). The shaded portion of each frame contains control slots. On the top row (Uplink RT) the mobile stations finds in a Y slot downlink transmission the slot addresses of the next available PRA slots, which are in the uplink frame of the same superframe. It transmits a PRA message and receives in the next downlink frame a PAG message allocating a slot from the uplink frame. Thereafter the mobile station uses this regularly occurring slot for uplink realtime transmission. On the second row (Downlink RT) the base station transmits a PP message that identifies a downlink information slot from the next complete downlink frame on. The mobile station responds with a PPA message, whereafter the downlink realtime transmission commences.

On the third row (Uplink NRT) of Figure 9, the mobile station transmits a PRA message after having found a correct PRA slot address in a received Y slot message. In the downlink frame of the next superframe the base station sends a PAG message that identifies an NRT control slot (NC) from the downlink frame of the third superframe. In the first NC slot the base station then transmits a message in which it gives an address for a downlink ARQ slot as well as the addresses for the first granted uplink NRT traffic slots. The first one(s) of the granted uplink NRT traffic slots may be in the uplink frame of the same superframe at earliest. The mobile station starts transmission in the allocated NRT traffic slots and the base station acknowledges the transmissions with ARQ messages and grants further uplink NRT traffic slots in the following NC slots. On the last row (Downlink NRT) the downlink non-realtime transmission starts with a PP message sent by the base station in a PP slot. The mobile station responds by sending, in a PPA slot identified in the PP message, a PPA message and optionally an empty ARQ message in the corresponding slot that was also identified in the PP message. The first downlink transmission will occur at earliest in the downlink frame of the next superframe. The mobile station acknowledges the downlink NRT transmission in its ARQ replies and the process continues until the non-realtime downlink data source has been exhausted (not shown in the Figure).

The radio resources control method according to the invention also offers a possibility for regulating the transmission power during radio connection. Above we referred to the fact that the control slots contained in the superframes form one or several logic control channels. One two-way logic channel per connection can be called a SCCH channel (system control channel), which in a preferred embodiment of the invention comprises, per each active connection, one slot (in the above given time-frequency space example one 200 kHz slot) per sixteen superframes both in the uplink and downlink directions. The SCCH channel is used for the whole duration of the active data transmission period, and it can be employed for instance for transmitting measurements relating to the power level, for arranging the mutual timing of the base station subsystem and the mobile station, for transmitting information relating to a handover to a different base station and for transmitting commands directed from the base station subsystem to the mobile station. The base station subsystem may for instance command the mobile station into a so-called sleep mode, where the mobile station is inactive for a predetermined period of time in order to save power.

Another possibility offered by the method according to the invention for regulating the power level of mobile stations is a public power control channel (PPCC) independent of the slot division in the frames. In order to realise it, each downlink frame comprises a given PPCC slot containing a given amount of power control bits per each possible slot in the corresponding uplink frame. The amount of power control bits in the PPCC slot can be chosen so that if the respective frame would be altogether composed of the smallest possible slots, each slot would have its own bits. When the frame in practice contains larger slots, too, in the controlling of each larger slot there are used all those bits of the PPCC slot that refer to the area of the larger slot. This arrangement is illustrated in Figure 10. The PPCC slot 47 comprises the first power control bits 48 and the second power control bits 49. If the corresponding uplink frame 50 would comprise only small slots 51 and 52, the first power control bits 48 would control the first slot 51 and the second power control bits 49 would control the second slot 52. If the small slots in the uplink frame are modularly replaced by a larger slot 53, the power control bits 48 and 49 control the same slot 53, which brings either more resolution or redundance to the control. Thus the structure of the PPCC slot can be independent of the slot structure of the frames in the uplink channel. A similar control channel structure and principle can also be applied in other types of radio resource control connected to the superframe. For example, the point of time of the

transmission of each slot can be controlled by a similar procedure.

The slot allocation principles that were presented previously may be applied also to the existing TDMA systems like the GSM system or the IS-136 system to increase the data transmission capacity of a given radio connection. The size of an allocated slot in a single frequency band will come bigger in the chronological direction if several consecutive slots of each cyclically repeated frame are given to a single connection. Alternatively or additionally the connection may get slots from both uplink and downlink frames, without the limitation that uplink frame slots should be for uplink use only and downlink frame slots for downlink use only. This means that the newly allocated larger slot would actually consist of at least two separate areas in the time-frequency space, with a forbidden separator frequency band separating the nominal "uplink" and "downlink" frequencies in a manner known as such from prior art.

Figure 12a shows a block diagram of a base station subsystem BSS according to the invention. The functions of the BSS are controlled by a microcontroller 200. The microcontroller 200 is in contact with a slot allocator 201, which performs the slot allocation according to calculations and/or an algorithm. Data of the different slots are stored as a a slot reservation table 202 in a memory. The table includes a list of uplink slots 202a and downlink slots 202b indicating size and state of each slot as well as any other possible parameters and which mobile station a slot is allocated to. According to the slot allocation information received from the slot allocator 201 the microcontroller controls the transceiver 203 of the BSS to function in transmission and reception according to the allocation. The transceiver 203 may include a packet former/deformer 205 for forming a data packet for transmission, whereafter a code adder 206 adds a code if code is one of the dimensions of the slot. A modulator 207 and a RF transmitter 208 modulate the signal to radio frequency and form the carrier signal which is then transmitted by the antenna 204. Accordingly blocks 205 - 208 form a slot under control of the microcontroller 200 in accordance with the slot allocation. In reception blocks 205 - 208 perform the reverse functions under control of the microcontroller 200. Blocks 200 - 202 may be part of the base station controller BSC or they may be included in the base station BTS. Blocks 203 - 204 are part of the base station BTS.

Figure 12b shows a block diagram of a mobile station subsystem MS according to the invention. The functions of the MS are controlled by a microcontroller 300. The microcontroller 300 is in contact with a slot table 301, which stores information about the slots allocated for the mobile station by the base station. The table includes a list of uplink slot(s) and downlink slot(s) indicating size as well as any other possible parameters. According to the slot table 301 the microcontroller controls the transceiver 303 of the MS to function in transmission and reception according to slot table. The transceiver 303 may include a packet former/deformer 305 for forming a data packet for transmission, whereafter a code adder 306 adds a code if code is one of the dimensions of the slot. A modulator 307 and a RF transmitter 308 modulate the signal to radio frequency and form the carrier signal which is then transmitted by the antenna 304. Accordingly blocks 305 - 308 form a slot under control of the microcontroller 300 in accordance with the slot table. In reception blocks 305 - 308 perform the reverse functions under control of the microcontroller 300.

In the specification above, we have described a method for controlling radio resources with reference to a few preferred embodiments. It is obvious for a man skilled in the art that the explained examples are not meant to be restrictive, but the invention can, according to ordinary professional skills, be modified within the scope of the appended patent claims.

Claims

1. A method for controlling physical radio resources in a radio system comprising a base station subsystem and several mobile stations in radio connection thereto, **characterised** in that the physical radio resources are divided into chronologically consecutive frames (14), said frames containing two-dimensional slots (16, 17, 18) having varying data transmission capacities, in which case

   - the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
   - each slot represents a given share of the physical resources contained in the frame,
   - a multitude of slots in at least one frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
   - the first dimension of the slots is time and the second dimension of the slots is one ofthe following: time, frequency, code;

   and the base station subsystem makes a decision of allocating the slots for the radio connections on the basis of

   - the data transmission needs of the radio connections,
   - the changes in the data transmission needs of the radio connections, and
   - the size and state of occupancy of the slots.

2. A method according to claim 1, **characterised** in that the slots contained in the frame belong, according to the volume of the respective physical radio resources, to at least two different allowed size cat-

egories, and that in order to change the slot structure of a frame, a predetermined integral number of the slots of the first size category can be replaced by a predetermined integral number of the slots of the second size category.

3. A method according to claim 2, **characterised** in that the amount of allowed size categories is three, in which case the slot (16) of the largest size category is equal to two slots (17) of the next largest size category or to ten slots (18) of the smallest size category.

4. A method according to claim 2, **characterised** in that the amount of allowed size categories is four, in which case the slot of the largest size category is equal to two slots of the next largest size category, four slots of the third largest size category or eight slots of the smallest size category.

5. A method according to claim 1, **characterised** in that each frame is divided. in the direction of the first dimension, to a predetermined amount of time slots (15), and each time slot is further divided into slots.

6. A method according to claim 5, **characterised** in that time-time-division is applied, whereby each slot occupies the whole frequency range of the corresponding time slot but the length of each slot in the time dimension depends on its data transmission capacity.

7. A method according to claim 5, **characterized** in that time-frequency division is applied, whereby each slot occupies the whole chronological duration of the corresponding time slot but the width of each slot in the frequency dimension depends on its data transmission capacity.

8. A method according to claim 5, **characterized** in that time-code division is applied, whereby each slot occupies the whole chronological duration of the corresponding time slot but the data transmission capacity of each slot depends on the corresponding spreading code.

9. A method according to claim 1, **characterised** in that a predetermined non-negative integral number of consecutive frames forms a superframe (19), so that in consecutive superframes, such frames that are located in similar positions when starting from the beginning of the superframe correspond to each other with respect to the slot division, if changes have not occurred in the data transmission need of the radio connections in between the superframes.

10. A method according to claim 9, **characterised** in that each superframe contains both slots (I) meant for transmission of information and control slots (C) for realising logic control channels.

11. A method according to claim 10, **characterised** in that a downlink signal comprises a general logic control channel (47) provided for the signalling connected to slotwise radio resource control.

12. A method according to claim 10, **characterised** in that each control slot (C) belongs, according to the physical radio resources represented thereby, to one of the allowed size categories.

13. A method according to claim 1, **characterised** in that a predetermined frequency band is used to convoy both downlink slots and uplink slots according to a time-division duplexing scheme.

14. A method according to claim 13, **characterised** in that a predetermined non-negative integral number of consecutive frames forms a superframe (19) and each superframe contains a first number of downlink frames and a second number of uplink frames.

15. A method according to claim 13, **characterised** in that a predetermined first frequency band is used to convoy nominally downlink slots and a predetermined second frequency band is used to convoy nominally uplink slots, but in response to unsymmetrical traffic conditions in uplink and downlink direction, slots are cross-allocated so that nominally downlink slots are used to convoy uplink traffic or nominally uplink slots are used to convoy downlink traffic.

16. A method according to claim 1, **characterised** in that the base station subsystem maintains a reservation table in order to indicate the size and state of occupancy of the slots in the frames and in order to maintain an optimal rate of usage.

17. A method according to claim 16, **characterised** in that the base station subsystem evaluates the quality of at least one allocatable slot and makes a decision of allocating or non-allocating said slot to a connection on the basis of the transmission quality required by said connection.

18. A method according to claim 16, **characterised** in that it comprises in the base station subsystem the steps in which, as a response to a slot request,

- either uplink or downlink frame storage is chosen,
- a frame storage is chosen,
- a set of candidate time slots from the chosen frame storage is formed,
- a set of predetermined selection criteria is ap-

plied to find the best candidate time slot,
- the transmission quality offered by the selected best candidate time slot is checked and
- a decision to allocate a slot from the best candidate time slot is made.

19. A method according to claim 16, **characterised** in that the base station subsystem makes a decision of allocating the slots for the radio connections also on the basis on the information contained in the reservation tables of neighbouring base station subsystems.

20. A method according to claim 19, **characterised** in that the base station subsystem allocates slots on the basis of the transmission power used for communication by different mobile stations, so that a first mobile station that uses low transmission power to communicate with a first base station will be allocated a slot that coincides chronologically with a slot allocated to a second mobile station that uses high transmission power to communicate with a second base station.

21. A method according to claim 19, **characterised** in that the base station subsystem allocates slots on the basis of the communication type used by different mobile stations, so that circuit-switched and packet-switched connections have their own slots located in the reservation tables of adjacent base stations in optimal locations with respect to the total interference of the system.

22. A method for setting up an uplink radio connection between a base station subsystem and a mobile station in a radio system comprising a base station subsystem and several mobile stations, in which radio system the physical radio resources are divided into chronologically consecutive frames (14), **characterized** in that said frames contain two-dimensional slots (16, 17, 18), in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: time, frequency, code;

and that the method comprises the steps of

- transmitting from the mobile station, in an allowed uplink capacity request slot, a capacity request (21, 35), where the mobile station indicates the amount of physical radio resources required by the radio connection, and
- making an allocation decision in the base station subsystem as a response to said capacity request.

23. A method according to claim 22, **characterised** in that the location and amount of the allowed uplink capacity request slots in relation to the frame structure is not constant and the base station subsystem transmits, in a predetermined downlink slot, an announcement indicating the location and amount of the allowed uplink capacity request slots.

24. A method according to claim 22, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised** in that in order to reserve radio resources for the use of a radio connection for uplink realtime data transmission services, the mobile station indicates in its capacity request (21) the required data transmission capacity.

25. A method according to claim 24, **characterised** in that the mobile station additionally indicates in its capacity request a predetermined set of parameters describing the required qualities of the radio connection.

26. A method according to claim 24, **characterised** in that when the data transmission capacity demand grows during an ongoing radio connection for uplink realtime data transmission services, the mobile station sends the base station subsystem a capacity request (24), where it indicates the required additional data transmission capacity.

27. A method according to claim 24, **characterised** in that when the data transmission capacity demand diminishes during an ongoing radio connection for uplink realtime data transmission services having several allocated slots, the mobile station leaves at least one of the allocated slots unused.

28. A method according to claim 24, **characterised** in that each mobile station has a certain temporary logic identifier in order to distinguish the mobile station from other mobile stations operating under the same base station subsystem, and in order to reserve radio resources for the use of a radio connection for parallel uplink realtime data transmission services, the mobile station sends the base station subsystem a capacity request where it indicates

- its temporary logic identifier
- the required parallel data transmission capacity, and

- an additional identifier, which distinguishes the parallel radio connection from other ongoing radio connections convoying realtime data transmission services.

29. A method according to claim 22, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised** in that in order to reserve radio resources for the use of a radio connection for uplink non-realtime data transmission services, the mobile station indicates in its capacity request (21) the amount of data to be transmitted.

30. A method according to claim 22, **characterised** in that in its allocation decision the base station subsystem has the freedom of directing the required radio connection into any available slot and after the allocation decision the base station subsystem transmits to the mobile station in a predetermined downlink access granting slot an indication of the granted slot or slots.

31. A method for setting up a downlink radio connection between a base station subsystem and a mobile station in a radio system comprising a base station subsystem and several mobile stations, in which radio system the physical radio resources are divided into chronologically consecutive frames (14), **characterized** in that said frames contain two-dimensional slots (16, 17, 18), in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: time, frequency, code;
  and that the method comprises the steps of
- making an allocation decision in the base station subsystem as a response to the detected need of a new downlink radio connection indicating the amount of physical radio resources required by the radio connection,
- transmitting from the base station subsystem to the mobile station a paging message (27, 28, 41, 42), that announces the location of the downlink slot or slots allocated to the radio connection in said allocation decision,
- as a response to a detected paging message, transmitting from the mobile station a paging acknowledgement message and
- as a response to a detected paging acknowledgement message, commencing downlink transmission from the base station subsystem.

32. A method according to claim 31, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised** in that in order to form a radio connection for downlink realtime data transmission services, the base station subsystem indicates in the paging message (27, 28), for the regularly repeated slots allocated to the radio connection, their location in relation to the frame structure.

33. A method according to claim 32, **characterised** in that when the data transmission capacity demand grows during an ongoing radio connection for downlink realtime data transmission services, the base station subsystem makes an additional slot allocation decision and sends the mobile station a paging message (27, 28, 41, 42), that announces the location of the additional downlink slot or slots allocated to the radio connection.

34. A method according to claim 32, **characterised** in that when the data transmission capacity demand diminishes during an ongoing radio connection for downlink realtime data transmission services having several allocated slots, the base station makes a slot deallocation decision concening at least one of the allocated slots and leaves the corresponding slots unused.

35. A method according to claim 32, **characterised** in that each mobile station has a given temporary logic identifier in order to distinguish the mobile station from other mobile stations operating under the same base station subsystem, and in order to reserve radio resources for the use of a radio connection for parallel downlink realtime data transmission services, the base station subsystem sends the mobile station a paging message, where it indicates

- the temporary logic identifier of the mobile station
- the location of the regularly repeated slots allocated to the parallel radio connection and
- an additional identifier, which distinguishes the parallel radio connection from other ongoing radio connections convoying realtime data transmission services.

36. A method according to claim 31, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised** in that in order to form a radio connection for downlink non-realtime data transmission services, the base station subsystem indicates in

the paging message (41[illegible]he location of the first slots for non-realtime data transmission services in relation to the frame structure, and to announce a change in either the location or the amount of the slots allocated for non-realtime data transmission services during the connection, the base station subsystem notifies the new location or amount of the slots by sending a new paging message.

37. A base station subsystem for a radio telecommunication system having base station subsystems and mobile stations, the base station subsystem having means for arranging the communicated information into chronologically consecutive frames, **characterised** in that the base station subsystem additionally comprises means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: time, frequency, code;

and the size of said slot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection.

38. A base station subsystem according to claim 37, **characterised** in that it further comprises means for maintaining a reservation table in order to indicate the size and state of occupancy of the slots in the frames and in order to maintain an optimal rate of usage.

39. A base station subsystem according to claim 38, **characterised** in that it further comprises means for communicating information concerning reservation tables with its neighbouring base station subsystems.

40. A base station subsystem according to claim 37, **characterized** in that in order to set up uplink connections it further comprises means for

- producing a general access slot location announcement and transmitting it to all mobile stations in a predetermined downlink slot in order to advice the mobile stations to send capacity requests i[illegible] announced access slot,
- receiving and interpreting capacity requests from the mobile stations,
- making slot allocation decisions that allocate slots to radio connections requested and identified in the capacity requests and
- producing access granting messages and transmitting them in a predetermined slot selectively to those mobile stations whose capacity requests were granted in the slot allocation decisions.

41. A base station subsystem according to claim 37, **characterized** in that in order to set up downlink connections it further comprises means for

- producing paging messages and transmitting them in a predetermined slot selectively to those mobile stations to which a downlink connection is to be established, said paging messages indicating at least one allocated downlink slot,
- receiving and interpreting paging acknowledgement messages from the mobile stations, and
- directing a downlink transmission into the allocated downlink slots indicated in the paging message.

42. A mobile station for a radio telecommunication system having base station subsystems and mobile stations, the mobile station having means for arranging the communicated information into chronologically consecutive frames, **characterised** in that the mobile station additionally comprises means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: time, frequency, code;

and the size of said slot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection.

43. A mobile station according to claim 42, **character-**

ized in that in order to s[illegible] uplink connections it further comprises means for

- receiving and interpreting access slot location announcements transmitted from a base station subsystem,
- producing a capacity request and transmitting it in an access slot identified in an access slot location announcement,
- receiving and interpreting an access grant message from the base station subsystem identifying at least one granted slot and
- directing information transmissions into said at least granted slot.

44. A mobile station according to claim 42, **characterized** in that in order to set up downlink connections it further comprises means for

- receiving and interpreting paging messages transmitted from a base station subsystem, said paging messages indicating at least one allocated downlink slot,
- producing a paging acknowledgement message and transmitting it in an acknowledgement slot, and
- receiving and interpreting downlink transmissions in said at least one allocated downlink slot.

45. A mobile station according to claim 44, **characterised** in that it further comprises means for identifying the acknowledgement slot on the basis of the information included in a paging message.

46. A radio telecommunication system having base station subsystems and mobile stations, the base station subsystems and mobile stations having means for arranging the communicated information into chronologically consecutive frames, **characterised** in that the base station subsystems and mobile stations additionally comprise means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: time, frequency, code;

and the size of sa[illegible]ot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection.

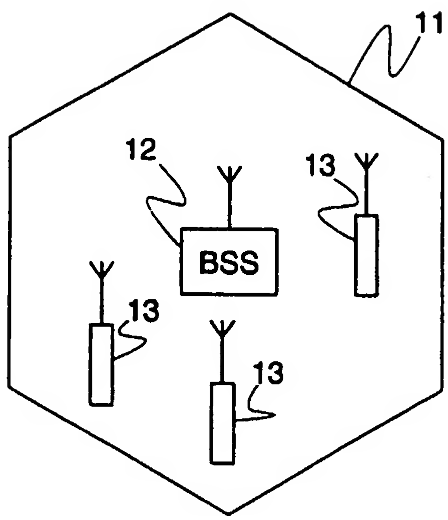


Fig.1
PRIOR ART

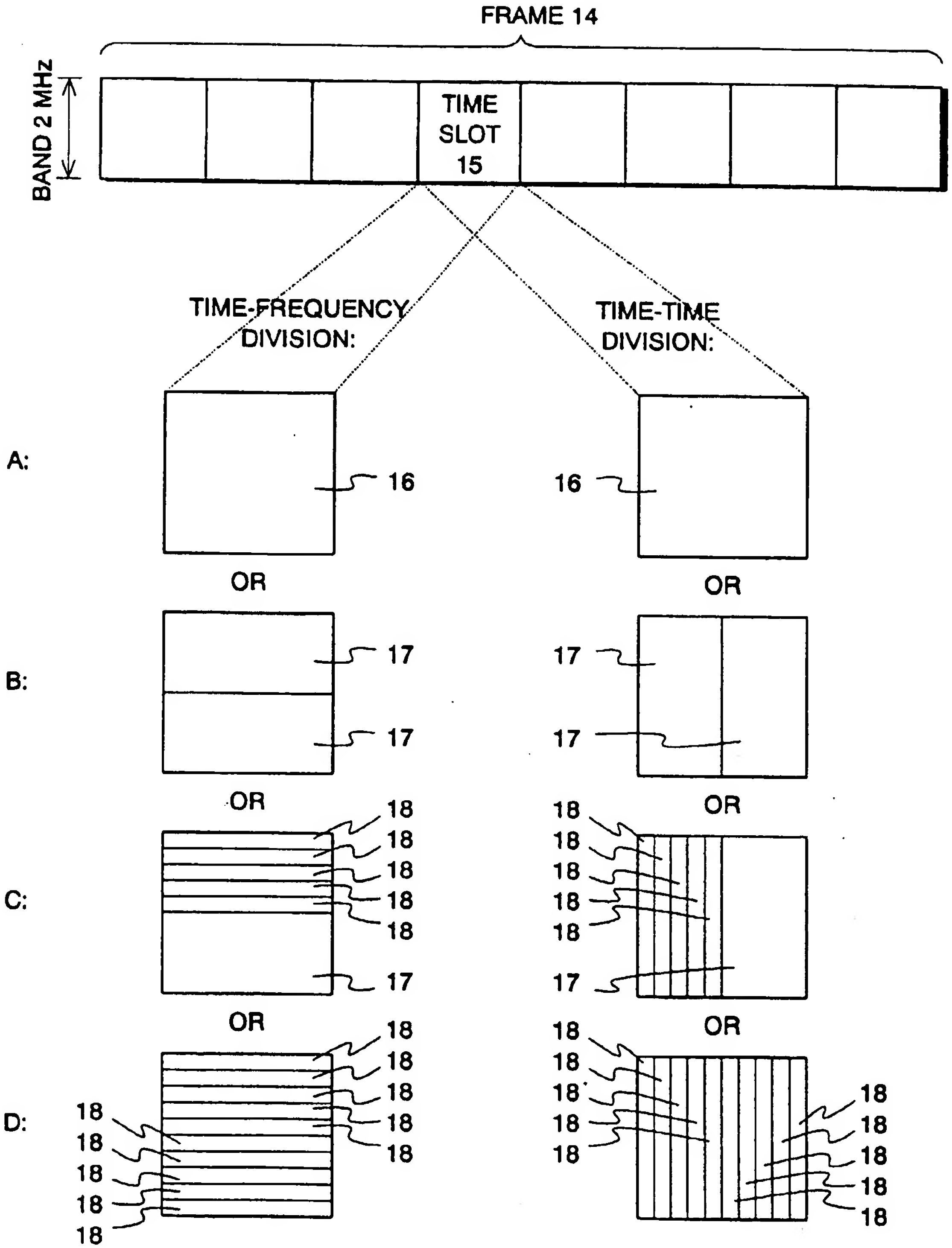

FRAME 14
BAND 2 MHz
TIME SLOT 15
TIME-FREQUENCY DIVISION:
TIME-TIME DIVISION:
A:
16
16
OR
OR
B:
17
17
17
17
OR
OR
C:
18
18
18
18
18
17
18
18
18
18
18
17
OR
OR
D:
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18
18

Fig. 2a

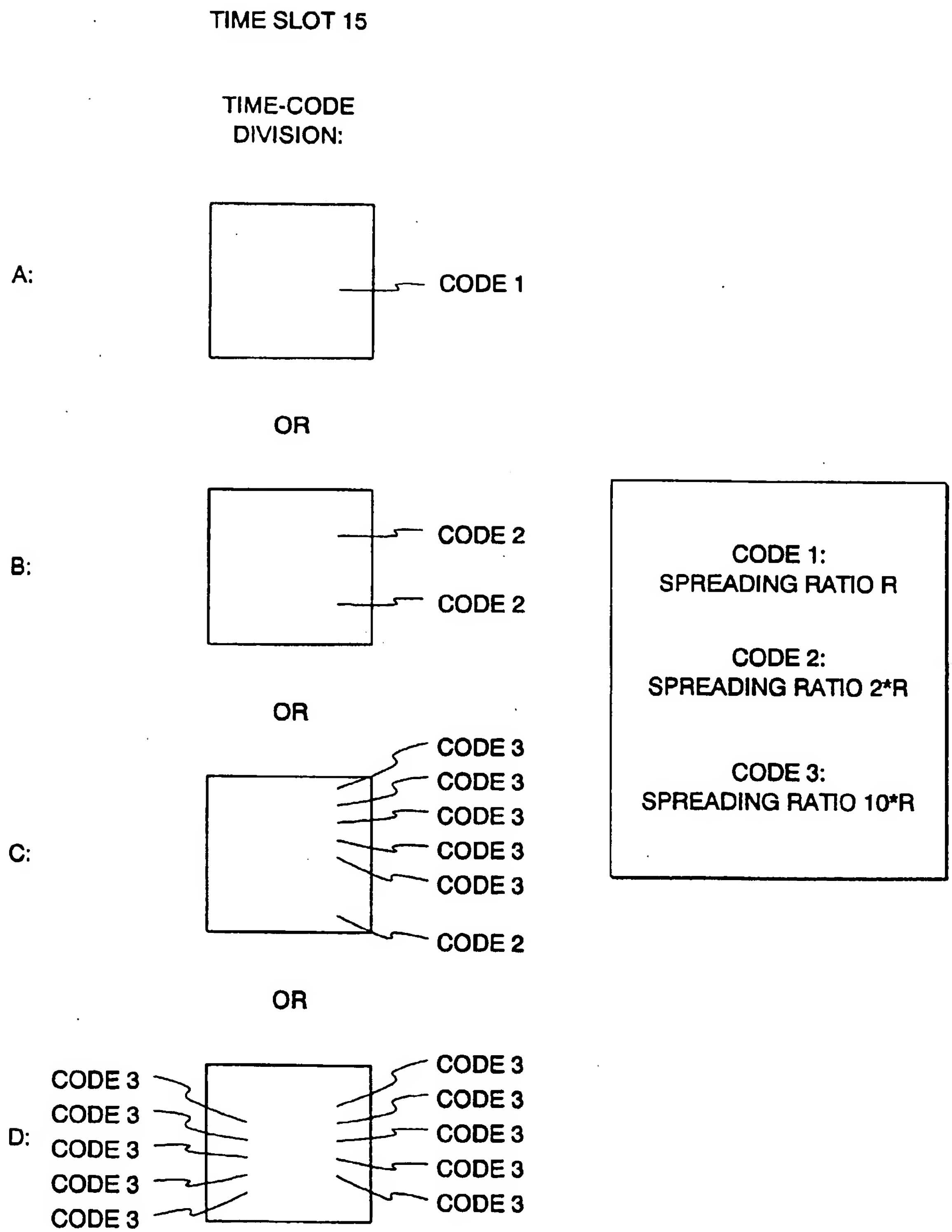

TIME SLOT 15
TIME-CODE DIVISION:
A:
CODE 1
OR
B:
CODE 2
CODE 2
OR
C:
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 2
OR
D:
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 1: SPREADING RATIO R
CODE 2: SPREADING RATIO 2*R
CODE 3: SPREADING RATIO 10*R

Fig. 2b

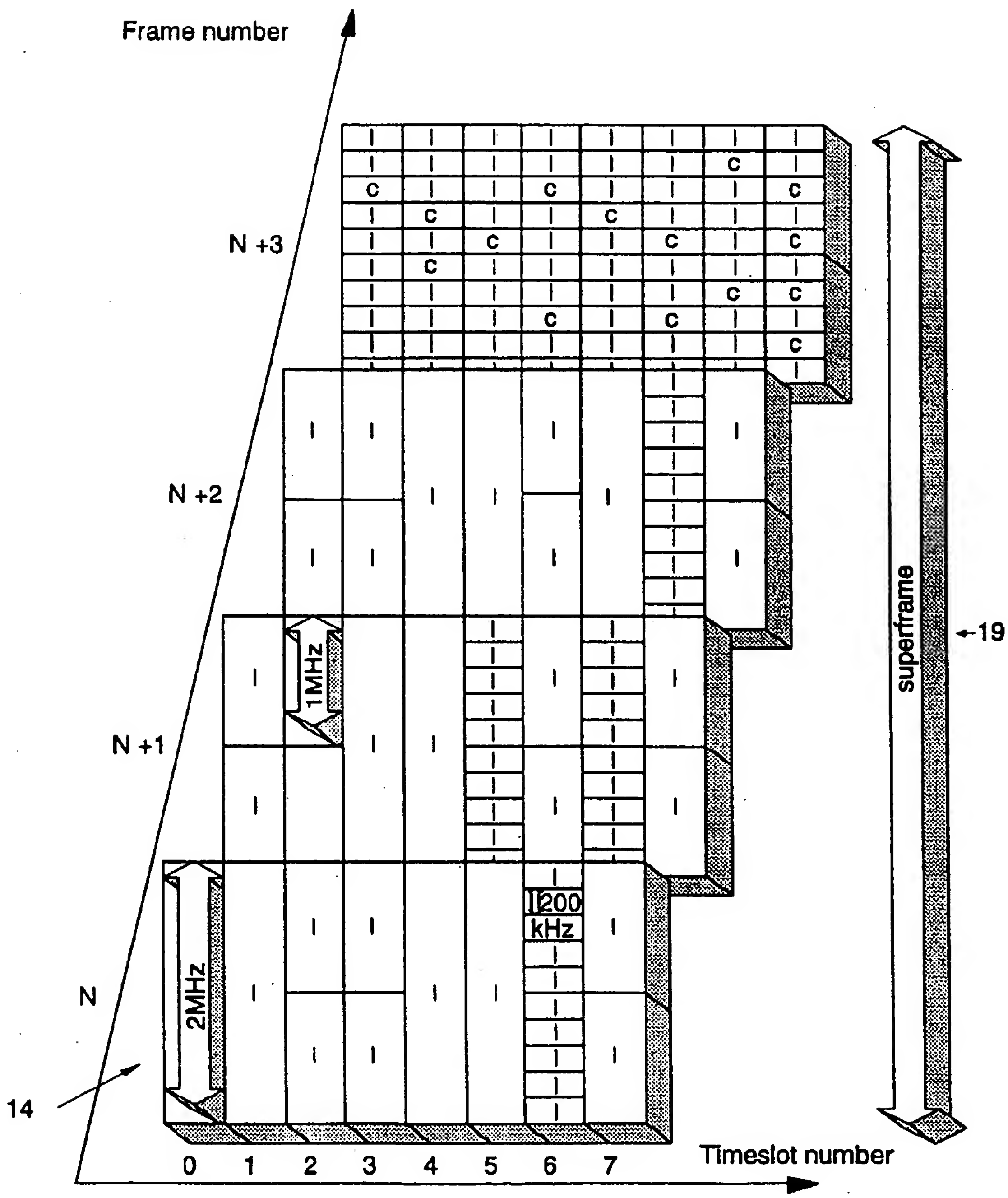

Frame number
N +3
N +2
N +1
N
14
2MHz
1MHz
200 kHz
superframe
19
Timeslot number
0
1
2
3
4
5
6
7
C
I

Fig.3

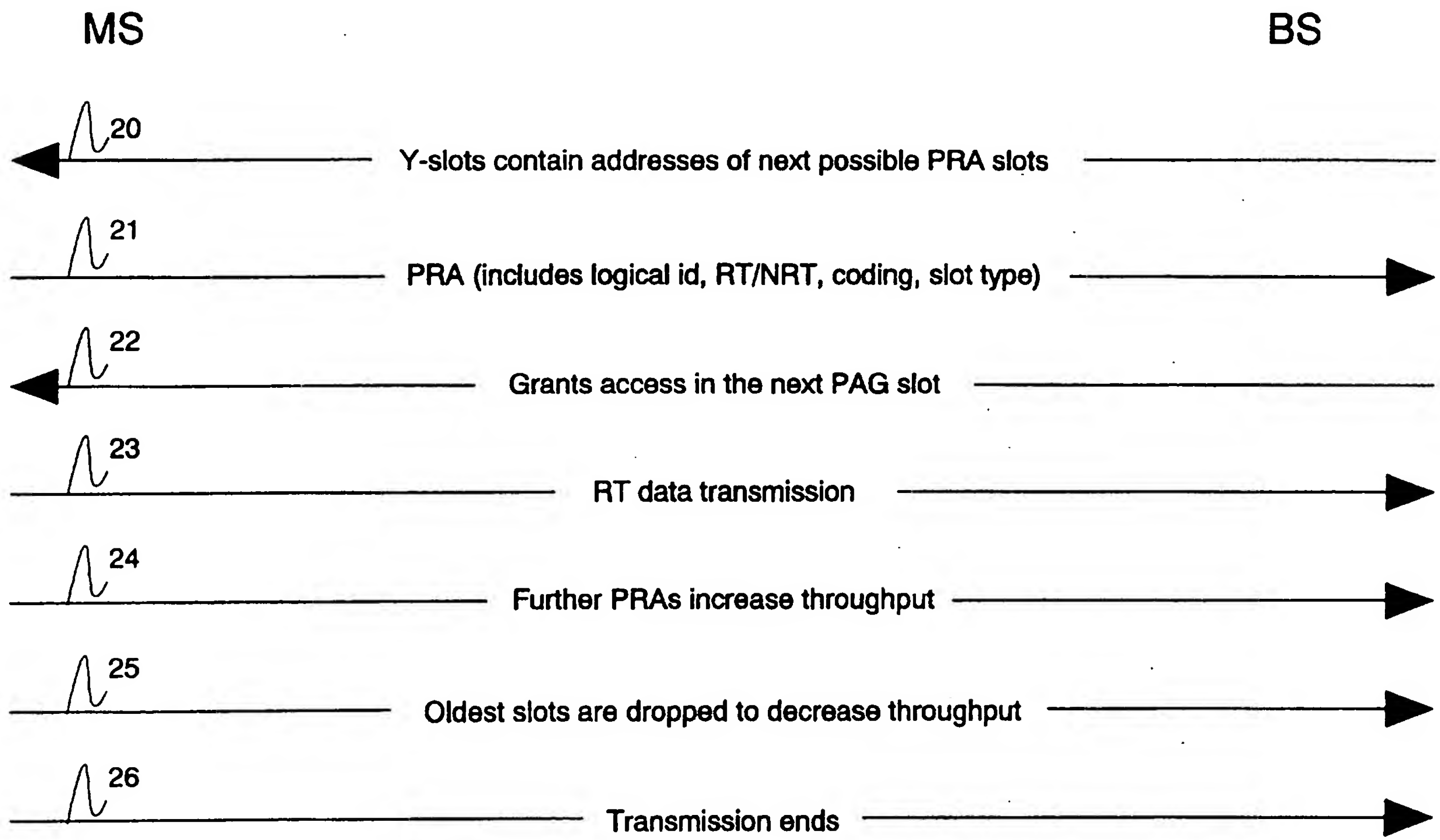

MS
BS
20
Y-slots contain addresses of next possible PRA slots
21
PRA (includes logical id, RT/NRT, coding, slot type)
22
Grants access in the next PAG slot
23
RT data transmission
24
Further PRAs increase throughput
25
Oldest slots are dropped to decrease throughput
26
Transmission ends

Fig. 4a

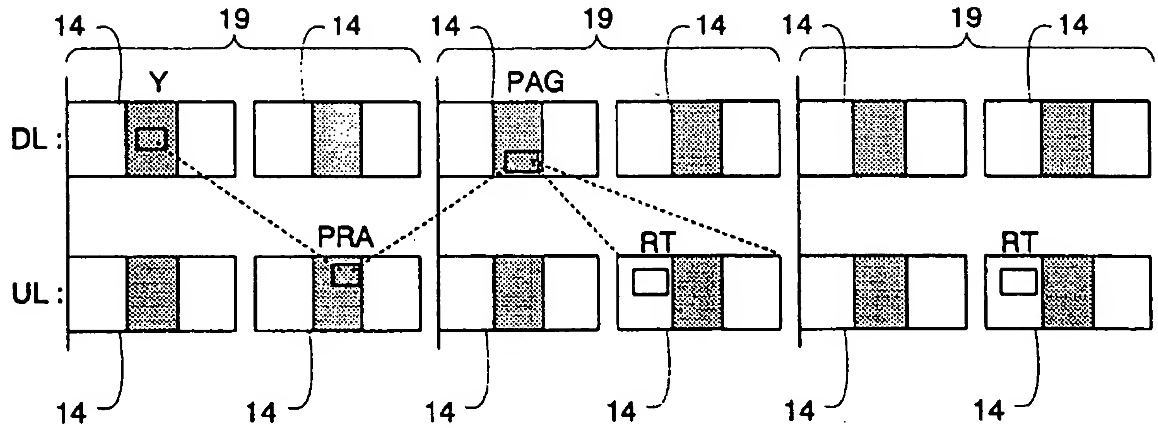

14
19
14
14
19
14
14
19
14
Y
PAG
DL :
PRA
RT
RT
UL :
14
14
14
14
14
14

Fig. 4b

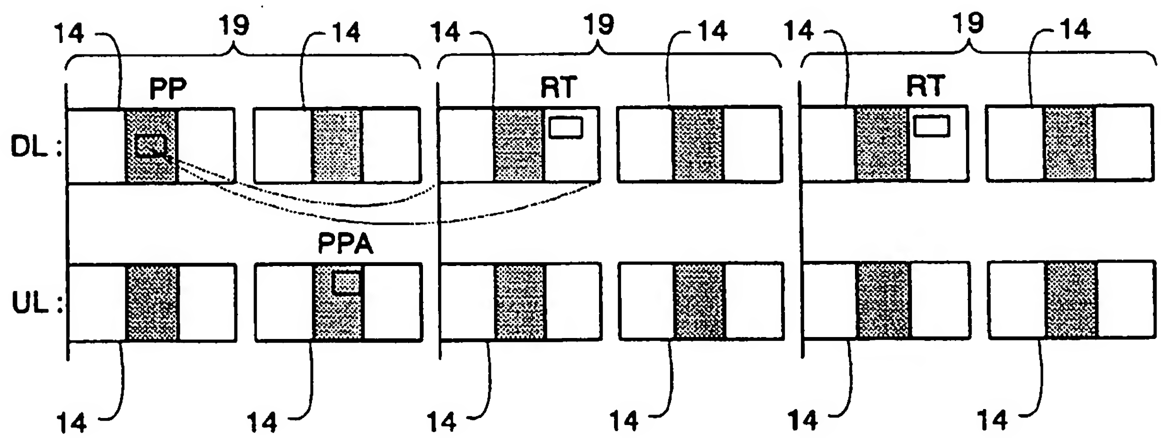

14
19
14
14
19
14
14
19
14
PP
RT
RT
DL :
PPA
UL :
14
14
14
14
14
14

Fig. 5b

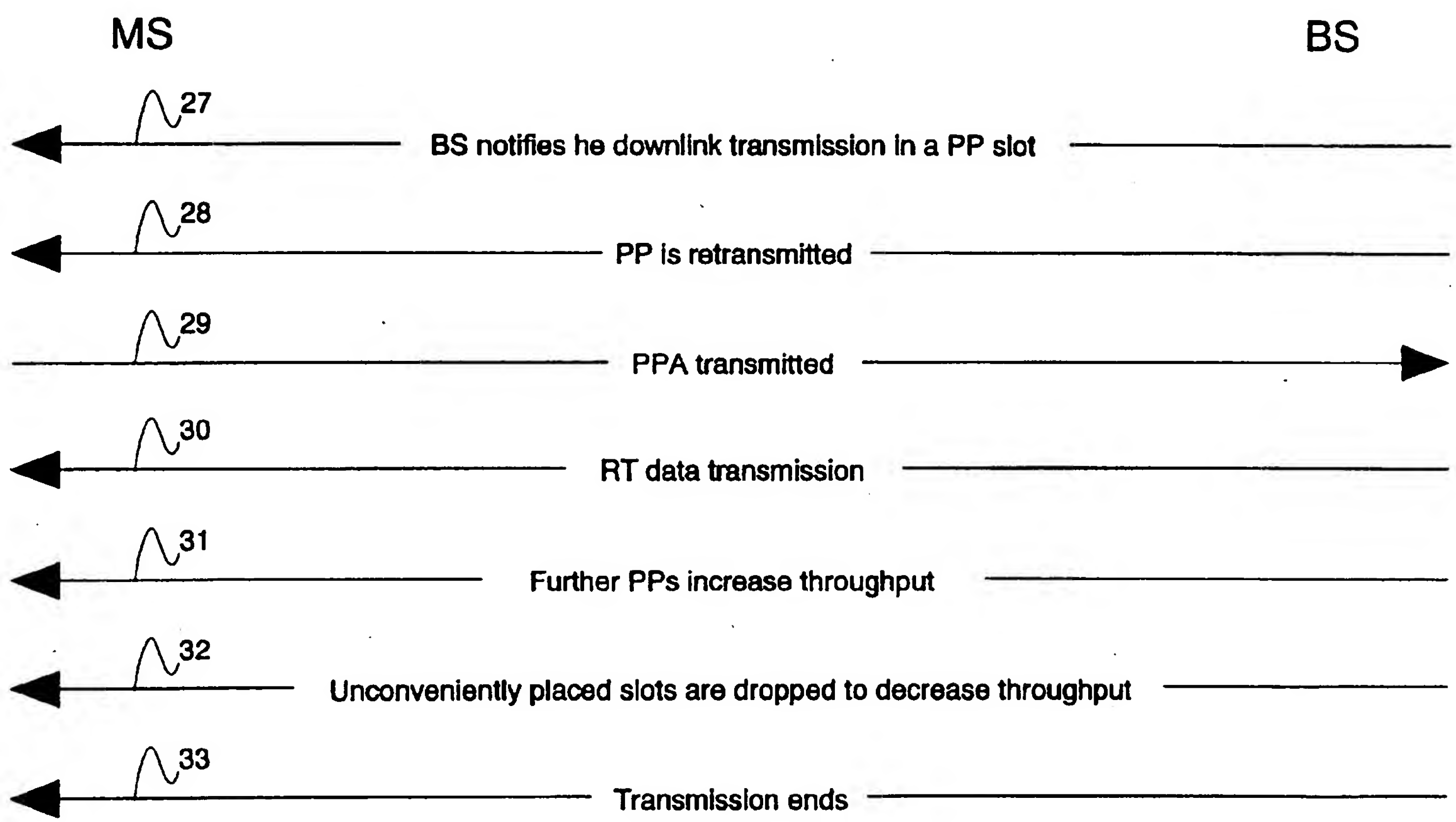

MS
BS
27
BS notifies he downlink transmission in a PP slot
28
PP is retransmitted
29
PPA transmitted
30
RT data transmission
31
Further PPs increase throughput
32
Unconveniently placed slots are dropped to decrease throughput
33
Transmission ends

Fig. 5a

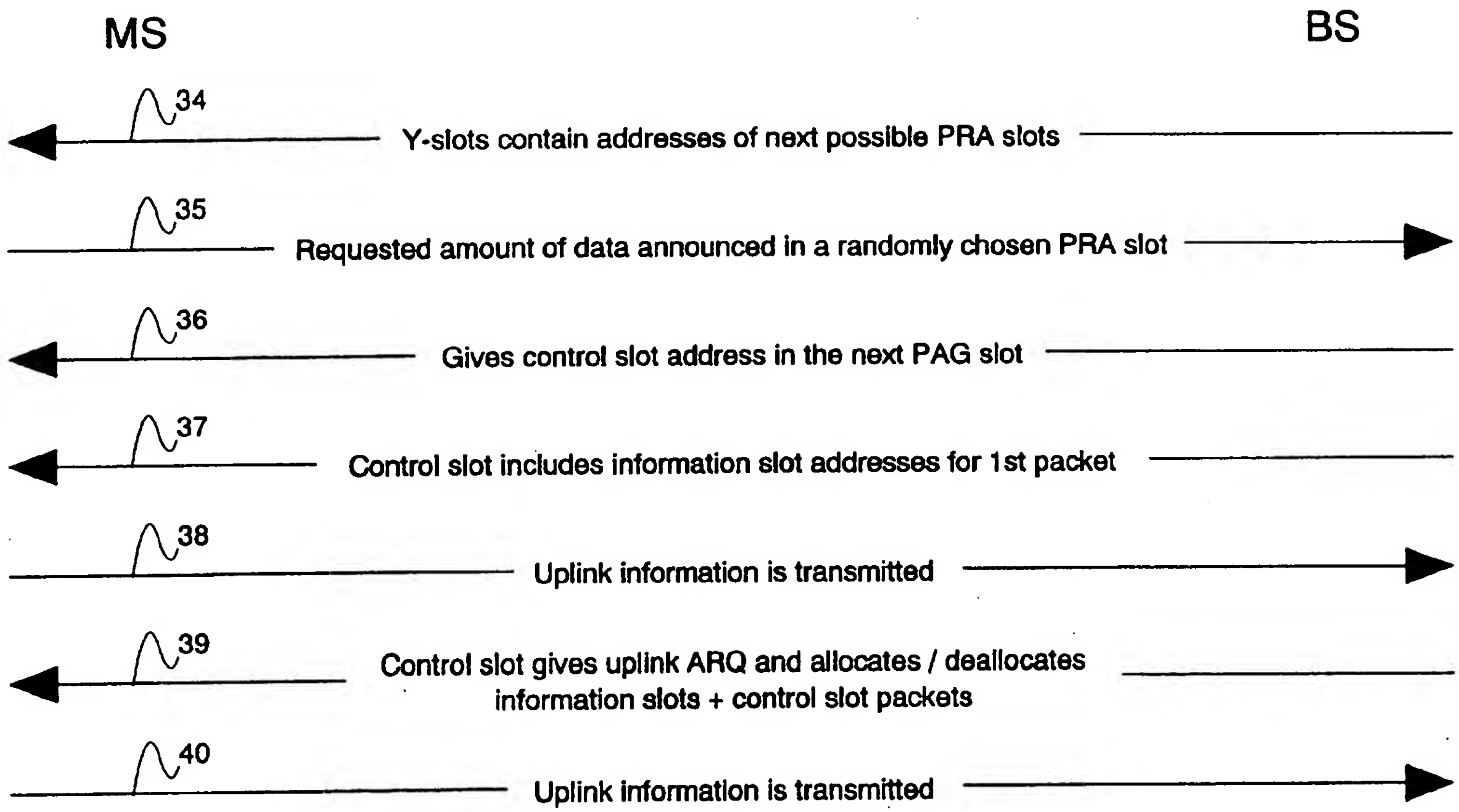

MS
BS
34
Y-slots contain addresses of next possible PRA slots
35
Requested amount of data announced in a randomly chosen PRA slot
36
Gives control slot address in the next PAG slot
37
Control slot includes information slot addresses for 1st packet
38
Uplink information is transmitted
39
Control slot gives uplink ARQ and allocates / deallocates information slots + control slot packets
40
Uplink information is transmitted

Fig. 6a

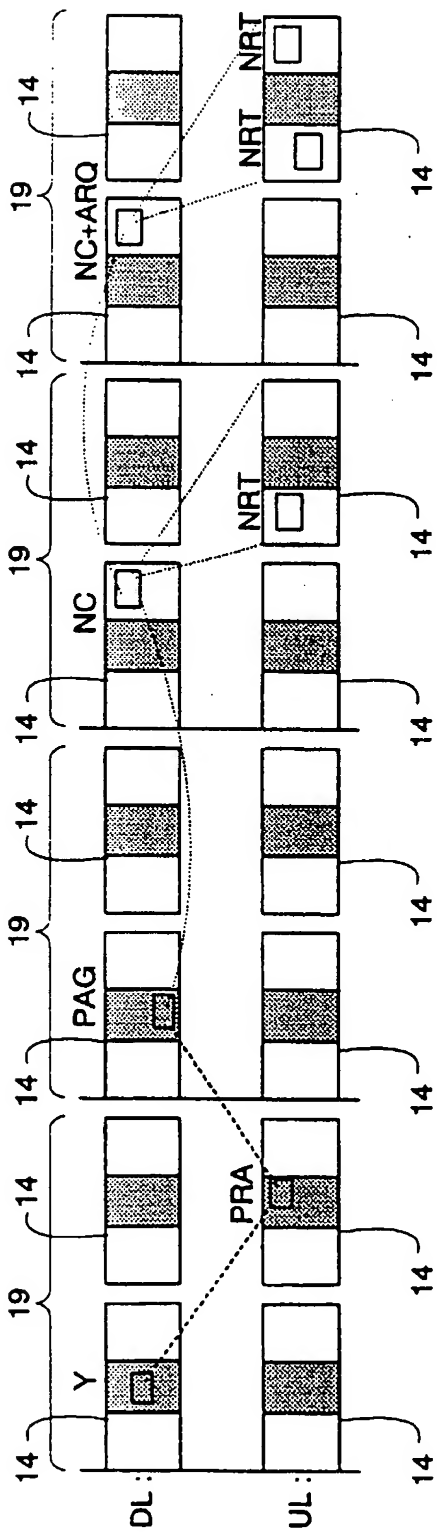


Fig. 6b

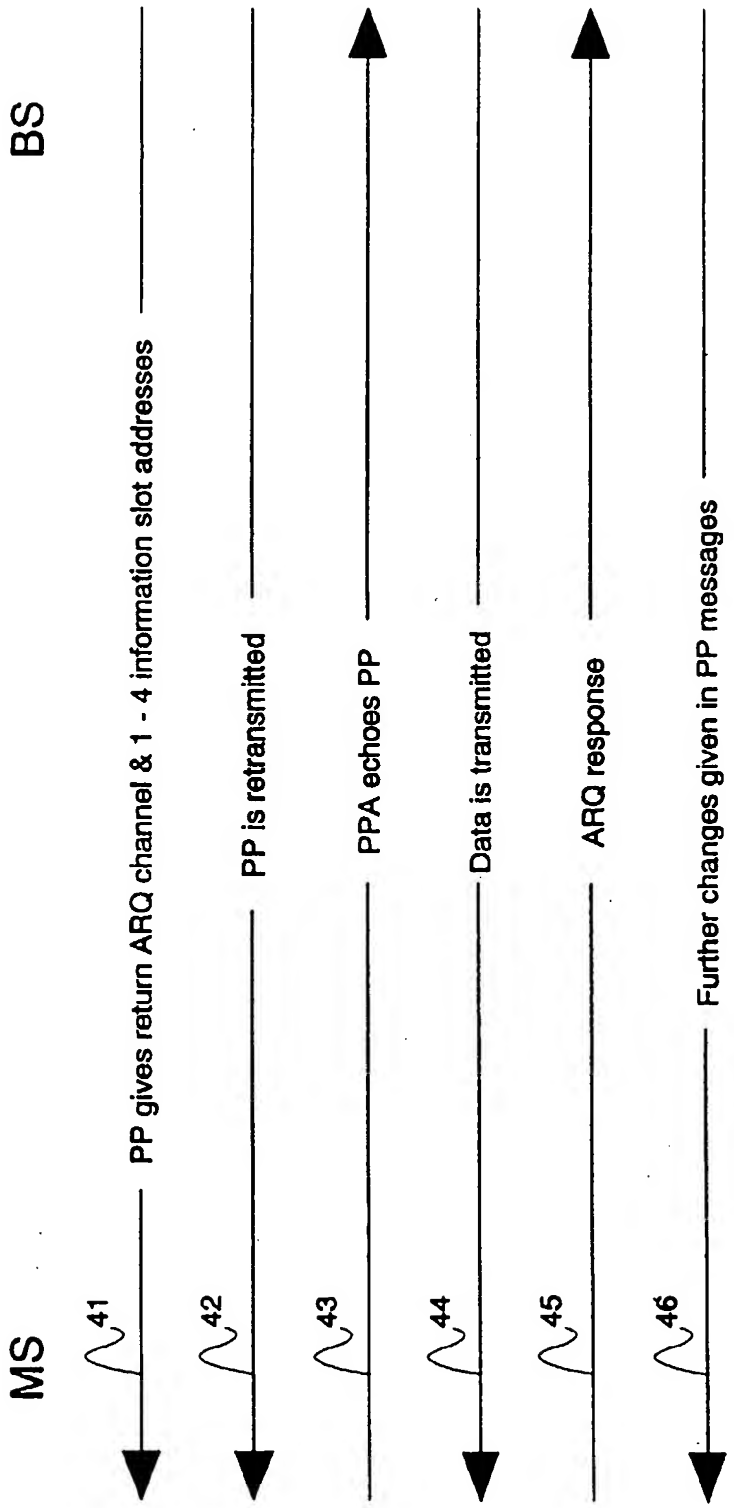

MS
BS
41
PP gives return ARQ channel & 1 - 4 information slot addresses
42
PP is retransmitted
43
PPA echoes PP
44
Data is transmitted
45
ARQ response
46
Further changes given in PP messages

Fig. 7a

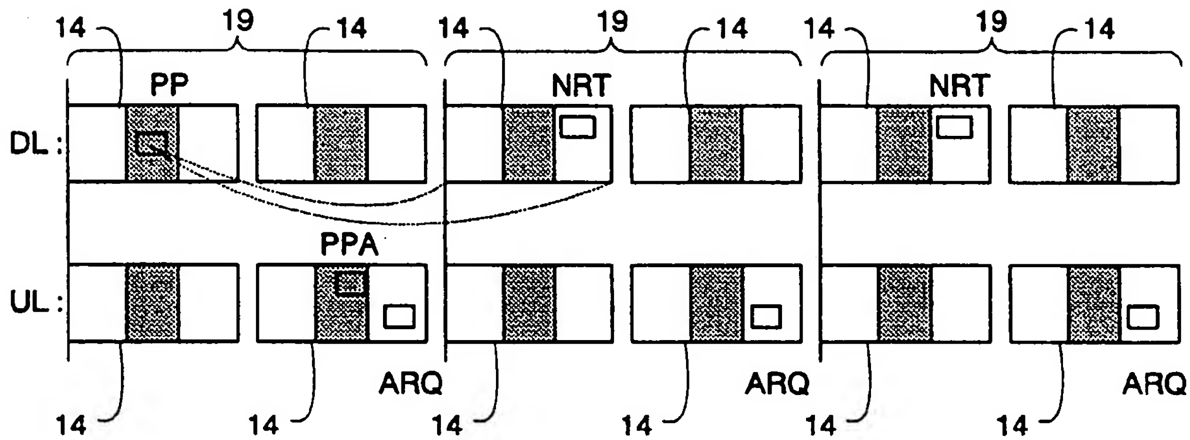

19
19
19
14
14
14
14
14
14
PP
NRT
NRT
DL :
PPA
UL :
ARQ
ARQ
ARQ
14
14
14
14
14
14

Fig. 7b

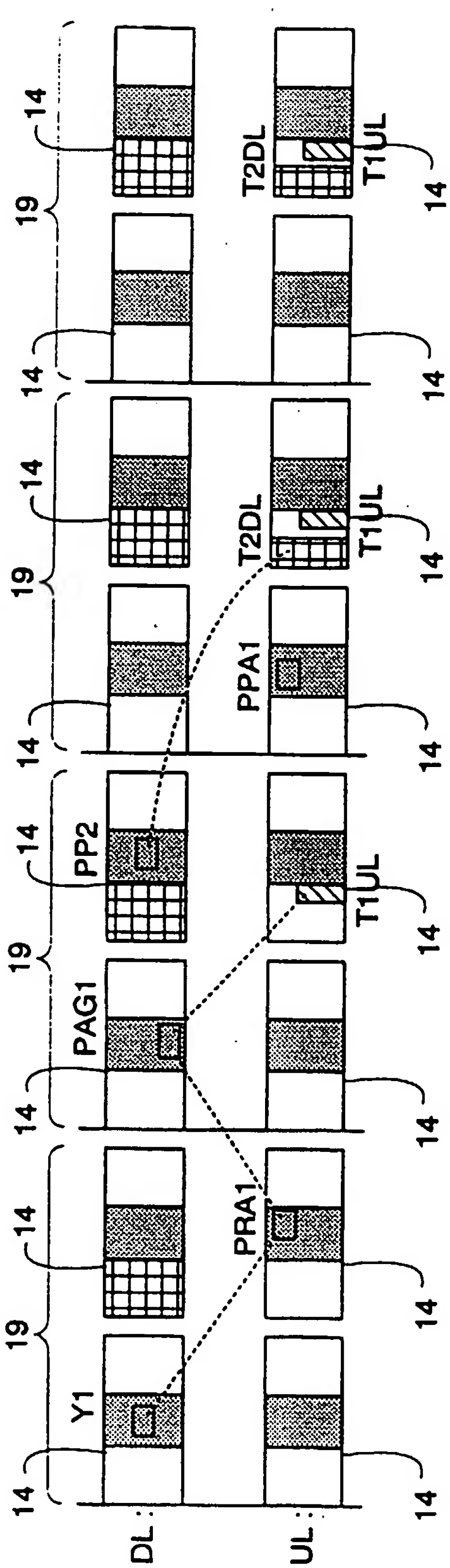


Fig. 8

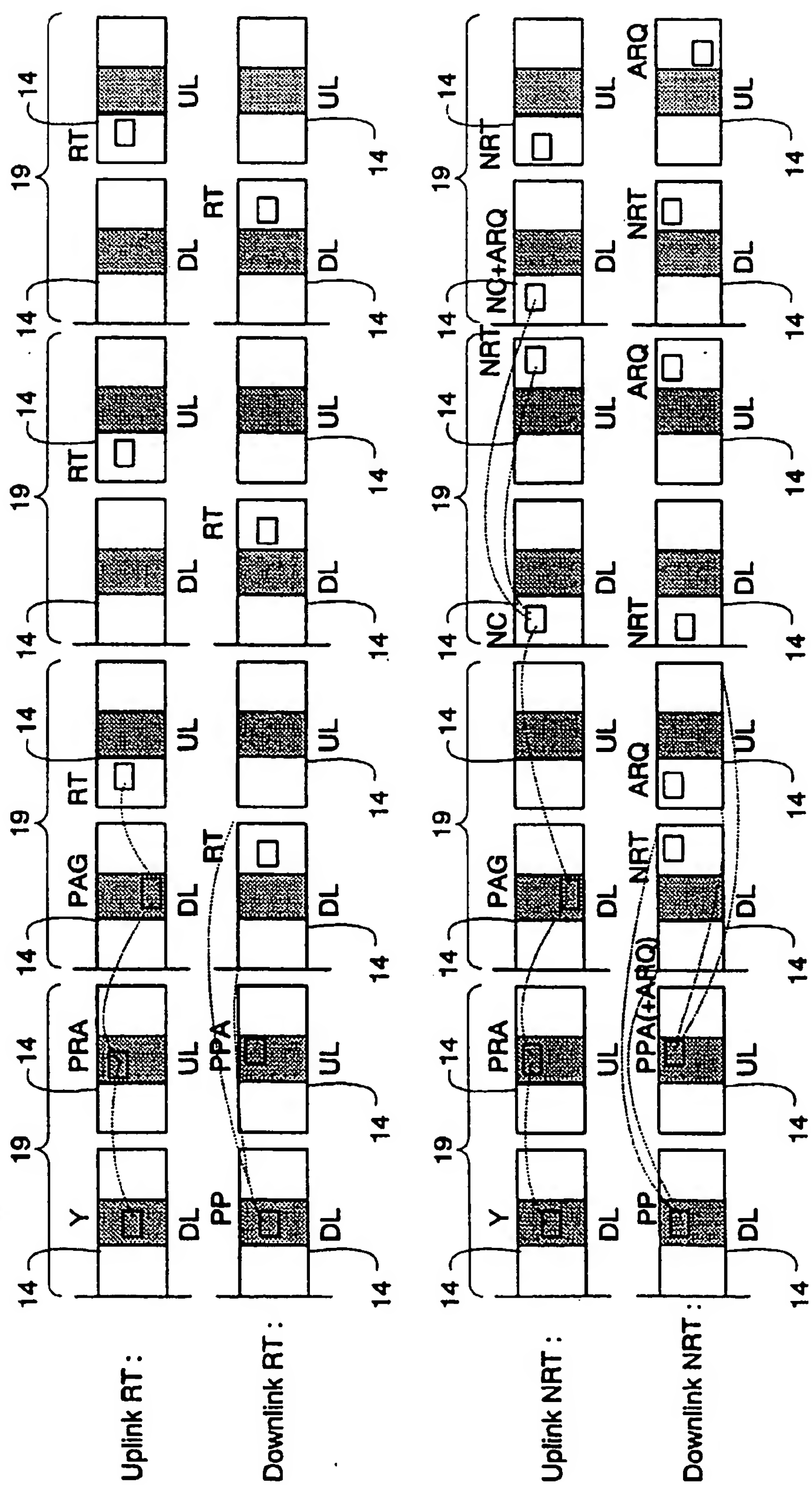

Uplink RT :
Downlink RT :
Uplink NRT :
Downlink NRT :
14
19
Y
PRA
PAG
RT
DL
UL
PP
PPA
NC
NRT
NC+ARQ
ARQ
PPA(+ARQ)

Fig. 9

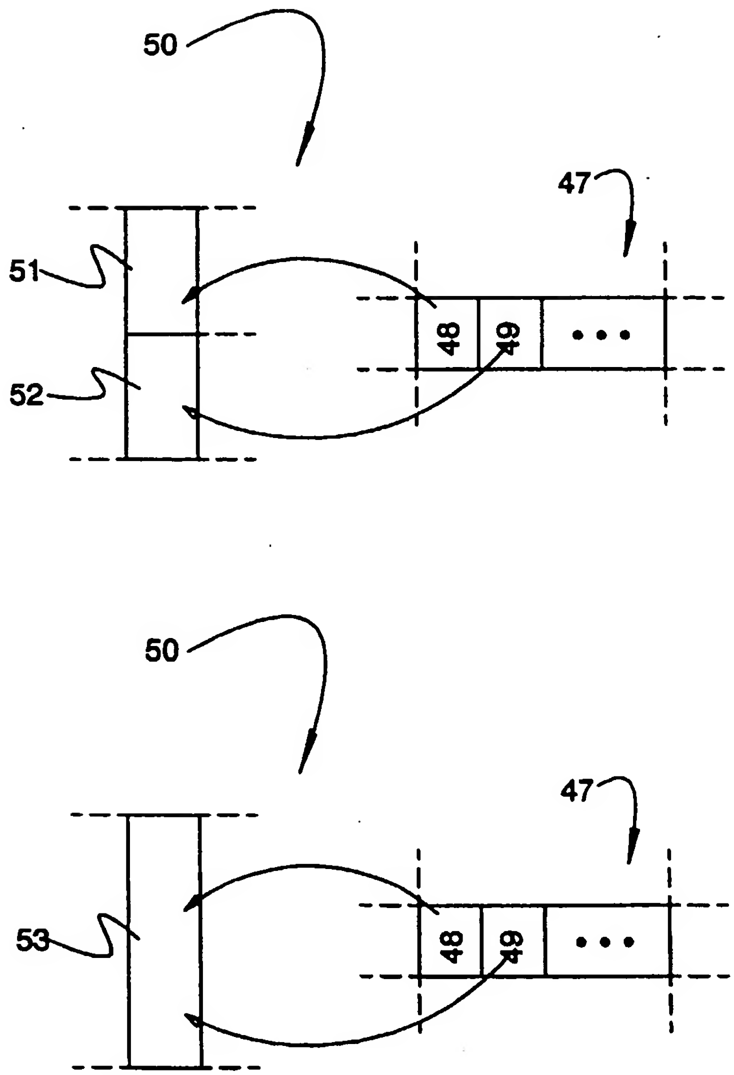
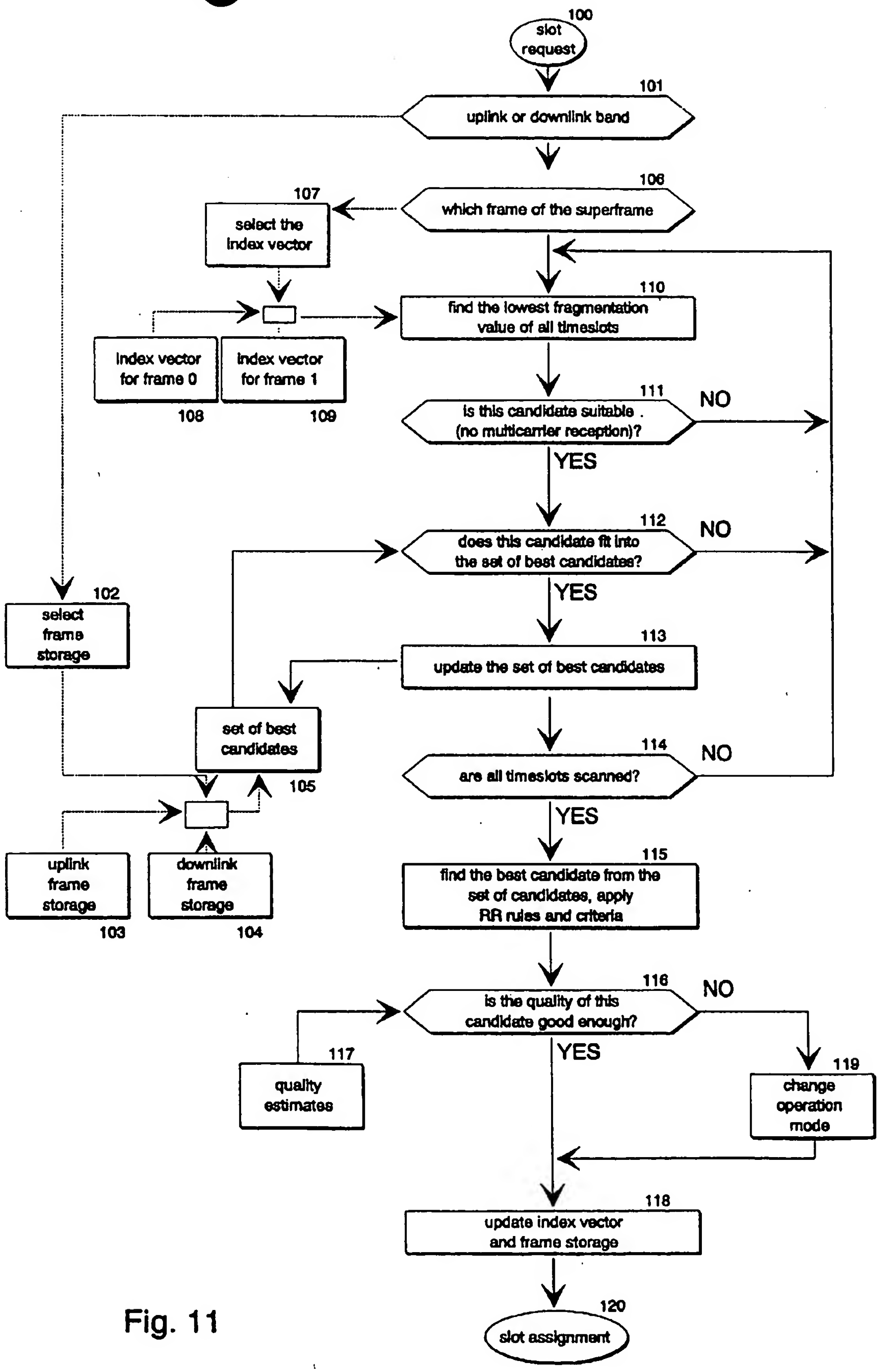


Fig. 10



100
slot request
101
uplink or downlink band
106
which frame of the superframe
107
select the index vector
index vector for frame 0
108
index vector for frame 1
109
110
find the lowest fragmentation value of all timeslots
111
is this candidate suitable (no multicarrier reception)?
NO
YES
112
does this candidate fit into the set of best candidates?
NO
YES
102
select frame storage
113
update the set of best candidates
set of best candidates
105
114
are all timeslots scanned?
NO
YES
uplink frame storage
103
downlink frame storage
104
115
find the best candidate from the set of candidates, apply RR rules and criteria
116
is the quality of this candidate good enough?
NO
YES
117
quality estimates
119
change operation mode
118
update index vector and frame storage
120
slot assignment

Fig. 11

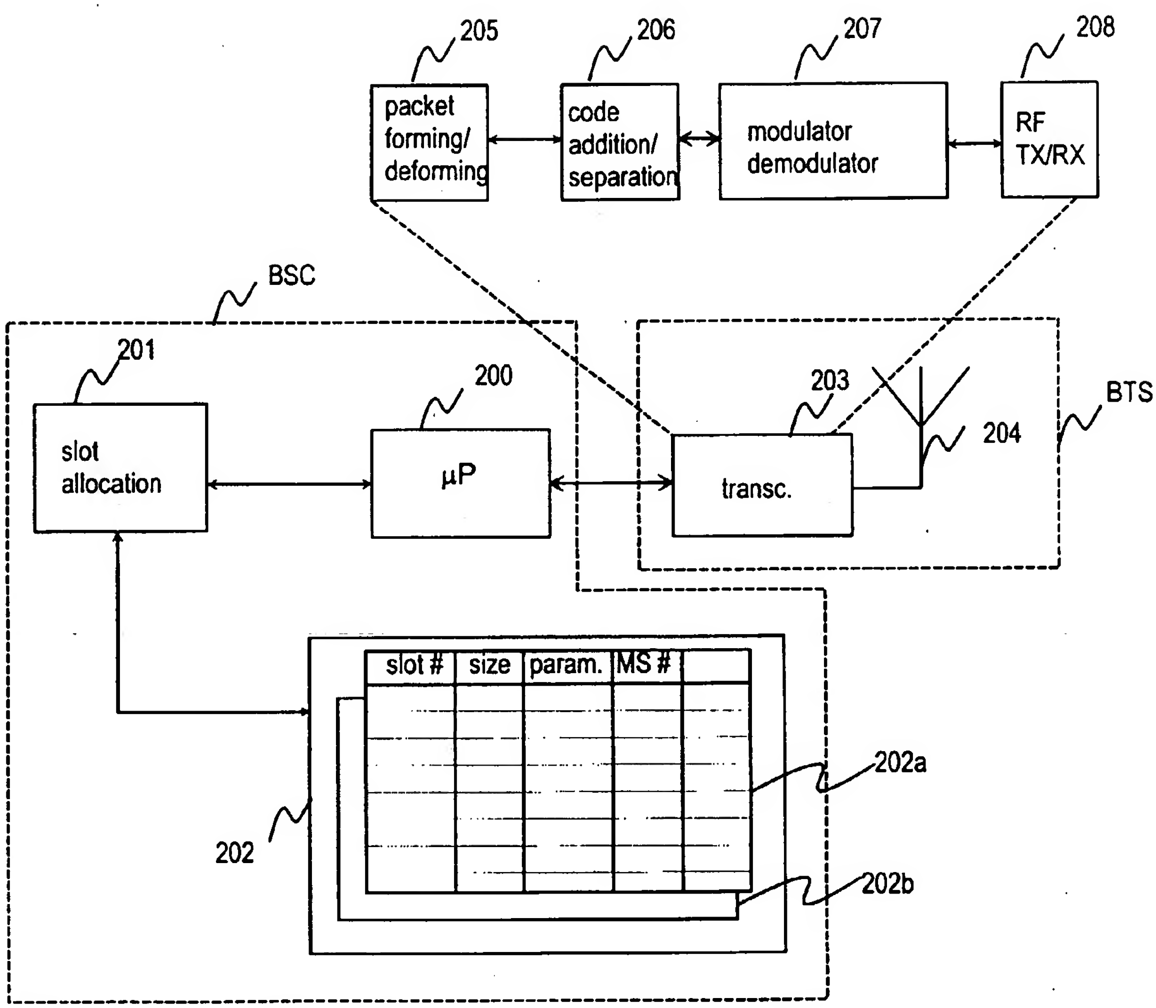

205
206
207
208
packet forming/ deforming
code addition/ separation
modulator demodulator
RF TX/RX
BSC
201
200
203
204
BTS
slot allocation
µP
transc.
slot #
size
param.
MS #
202a
202
202b

Fig. 12a

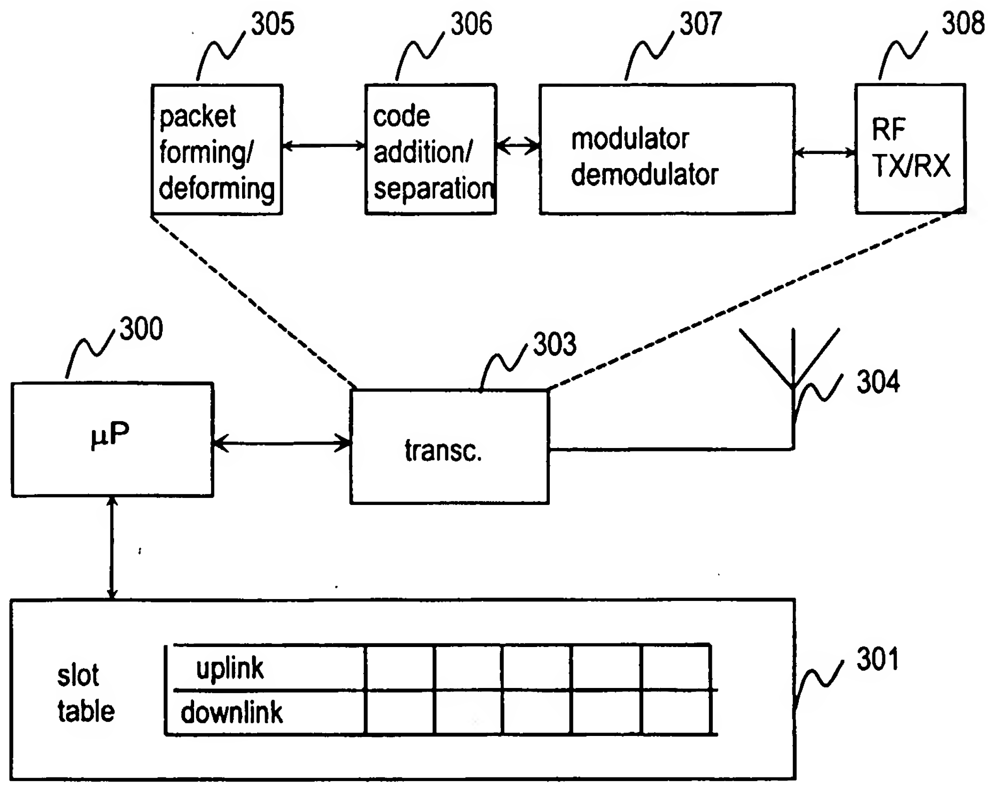

305
306
307
308
packet forming/ deforming
code addition/ separation
modulator demodulator
RF TX/RX
300
303
304
μP
transc.
slot table
uplink
downlink
301

Fig. 12b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 66 0109

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	US 5 533 004 A (JASPER STEVEN C ET AL) 2 July 1996 * column 2, line 34 - column 4, line 34 *	1,22,31, 37,42,46	H04B7/26
A,D	IKEDA T ET AL: "TDMA BASED ADAPTIVE MODULATION WITH DYNAMIC CHANNEL ASSIGNMENT (AMDCA) FOR LARGE CAPACITY VOICE TRANSMISSION IN MICROCELLULAR SYSTEMS" ELECTRONICS LETTERS, vol. 32, no. 13, 20 June 1996, page 1175/1176 XP000599175 * the whole document *	1,22,31, 37,42,46	
A,D	GB 2 174 571 A (INT MOBILE MACHINES) 5 November 1986 * page 7, line 52 - page 12, line 10 *	1,22,31, 37,42,46	
A,D	EP 0 633 671 A (NOKIA MOBILE PHONES LTD) 11 January 1995 * column 3, line 1 - column 5, line 22 *	1,22,31, 37,42,46	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H04B
H04Q
H04J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 March 1998	Gastaldi, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 841 763 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.12.2003 Bulletin 2003/50

(51) Int Cl.7: **H04B 7/26**

(21) Application number: **97660109.6**

(22) Date of filing: **16.10.1997**

(54) **Method for radio resource control**

Verfahren zur Funkkapazitätskontrolle

Procédé de contrôle de ressources radio

(84) Designated Contracting States:
DE ES FR GB IT NL SE

(30) Priority: **25.10.1996 FI 964308**
19.02.1997 US 802645

(43) Date of publication of application:
13.05.1998 Bulletin 1998/20

(73) Proprietor: **Nokia Corporation**
02150 Espoo (FI)

(72) Inventors:
- **Rikkinen, Kari**
FIN-04460 Nummenkylä (FI)
- **Rinne, Mikko J.**
00650 Helsinki (FI)
- **Ahmavaara, Kalle**
00330 Helsinki (FI)
- **Rinne, Mika**
02320 Espoo (FI)

(74) Representative: **Johansson, Folke Anders et al**
Nokia Corporation
P.O. Box 226
00045 Nokia Group (FI)

(56) References cited:
EP-A- 0 633 671 **GB-A- 2 174 571**
US-A- 5 533 004

- **IKEDA T ET AL: "TDMA BASED ADAPTIVE MODULATION WITH DYNAMIC CHANNEL ASSIGNMENT (AMDCA) FOR LARGE CAPACITY VOICE TRANSMISSION IN MICROCELLULAR SYSTEMS" ELECTRONICS LETTERS, vol. 32, no. 13, 20 June 1996, page 1175/1176 XP000599175**
- **Baier A. et al. "Design Study for a CDMA-Based Third-Generation Mobile Radio System"; May 1994**
- **ETS 300 175-1, Ed. 2; Sept. 1996**
- **ETS 300 175-2, Ed. 2; Sept. 1996**

EP 0 841 763 B1

Description

TECHNOLOGICAL FIELD

[0001] The invention relates generally to sharing radio resources between various users in a cellular radio system. Particularly the invention relates to sharing radio resources in a system where the users' data transmission needs, both in quality and quantity, change rapidly.

BACKGROUND OF THE INVENTION

[0002] At the moment of filing this application, the most general form of mobile personal telecommunication is a second-generation digital cellular radio network; these networks include the European systems GSM (Global system for Mobile telecommunications) and its extension DCS 1800 (Digital Communications System at 1800 MHz), the North American (USA) systems IS-136 (Interim Standard 136), IS-95 (Interim Standard 95) and the Japanese system PDC (Personal Digital Cellular). These systems transmit mainly speech, telefaxes and short text messages, as well as digital data at a limited speed, for instance files transmitted between computers. Several third-generation systems are being designed, the aims being world-wide coverage, a large selection of data transmission services and a flexible sharing of capacity, so that a given user may, when desired, transmit and/or receive even a large amount of data at a high speed.

[0003] The European Telecommunications Standards Institute ETSI has suggested a third-generation mobile telecommunications system called UMTS (Universal Mobile Telecommunications System). Its aim is a wide operating environment including homes, offices, urban and rural environments as well as stationary and mobile stations. The selection of services is large, and in addition to the currently known mobile telephones, the types of mobile stations include for instance multimedia terminals and multipurpose terminals that mediate telecommunications between the UMTS system and various local systems.

[0004] Figure 1 illustrates an exemplary cell 11 of the UMTS system, provided with a stationary base station subsystem 12 (BSS), within the range of which there exist or move, along with the users, several different mobile stations 13. The base station subsystem may comprise one or several base stations, as well as a base station controller controlling their operation. In between the base station subsystem and the mobile stations, there is a radio connection, for which a given radio frequency range is reserved, and the operation of which is regulated by the specifications of the system. The time and frequency range available for the radio connection together define so-called physical radio resources. One of the biggest challenges of the base station subsystem is to control the use of these physical radio resources so that all terminals located in the cell coverage are at any moment capable of receiving data transmission services of the requested quality, and that adjacent cells interfere with each other as little as possible.

[0005] From the prior art systems, there are known several methods for sharing radio resources. In time division multiple access (TDMA), each of the employed transmission and reception frequency bands is divided into time slots, among which the base station subsystem allocates one or several cyclically repeated time slots to the use of a given terminal. In frequency division multiple access (FDMA), the utilised frequency range is divided into very narrow bands, among which the base station subsystem allocates one or several to each terminal. Many current systems apply a combination of these, where each narrow frequency band is further divided into time slots. In coded division multiple access (CDMA), each connection between the mobile station and the base station subsystem obtains a spreading code, whereby the transmitted information is spread randomly within a fairly large frequency range. The codes used within the cell coverage are mutually orthogonal or nearly orthogonal, in which case a receiver that recognises the code may distinguish the desired signal and attenuate other simultaneous signals. In orthogonal frequency division multiplex (OFDM), suited mainly for broadcasting-type services, data is transmitted from the transmitting central station on a wide frequency band, which is divided into equidistant sub-frequencies, and the simultaneous phase shifts of these sub-frequencies create a two-dimensional bit flow in the time-frequency space.

[0006] As for the technology of packet switched radio networks, there are also known various packet-based connection protocols, where the connection between the mobile station and the base station subsystemis not continuous but proceeds in packages with pauses of varying durations in between. Compared with continuous connection systems, i.e. with so-called circuit-switched networks, there is achieved the advantage that the radio resources required by a given connection are not unnecessarily occupied when there is a temporary pause in the connection. A drawback is generally a longer data transmission delay, because after each pause, the transmission of a new packet requires the exchange of certain control or signalling messages between the mobile station and the base station. Delays can also be caused by different routing of the packages between transmitter and receiver.

[0007] It is typical of third-generation cellular radio networks that for instance in the case of Figure 1, with some of the terminals 13 it suffices to have a fairly low-capacity radio connection with the base station, but some of them need, at least temporarily, a remarkably larger share of the common radio resources than the others. Low-capacity connections can be for example speech connections, and a high-capacity connection can be for example the loading of an image file in a data network connection via the base station subsystem to

the mobile station, or a video image connection during a videophone call. In the prior art, there is not known a method where the base station subsystem could divide the available radio resources in a flexible and dynamic way between the various users. Some related prior art methods are discussed in the following.

[0008] US Patent No. 5 533 044 discloses a frame structure where the size of each time slot is the same. Different amounts of data may be transferred in each time slot by choosing the modulation method according to need.

[0009] The article "TDMA Based Adaptive Modulation with Dynamic Channel Assignment (AMDCA) for Large Capacity Voice Transmission in Microcellular Systems" by T. Ikeda et al in Electronics Letters, vol. 32, no. 13, 20 June 1996, pages 1175 - 1176, discloses another frame structure with a multiple of equally sized slots. Each connection has the same data rate, but different modulation methods are employed to compensate for the varying connection quality. A troubled connection is given more slots than the connections with better quality, so that the troubled connection may employ a more robust modulation scheme.

[0010] Patent document No. GB 2 174 571 discloses a frame structure that may accommodate a varying number of time slots. Each connection has the same data rate, but different modulation schemes are again used to provide robustness against noise and interference. The length of each time slot in a frame depends on the modulation method used in the connection to which the time slot has been allocated.

[0011] Patent document No. EP 633 671 describes a method for multiplexing the acknowledgement messages used in a packet switched radio communication system. Instead of letting every mobile station transmit its acknowledgement messages freely in a Random Access (RA) slot the system divides the RA slot into subslots by cutting it into shorter time intervals or allocating orthogonal codes for the duration of the RA slot. Only one mobile station or a small group of mobile stations is allowed to transmit in each subslot to reduce the risk of acknowledgement messages colliding with each other.

[0012] A standard specification for the DECT standard, namely document ETS 300 175-2 Second edition, September 1996 discloses the use of full-slots, half-slots and double-slots. Also, another DECT standard document, namely document ETS 300 175-1 Second edition, September 1996 discloses dynamic channel allocation where a selection of channels is made prior to their use.

[0013] Further document Baier A. et al. "Design Study for a CDMA-Based Third-Generation Mobile Radio System", May 1994 discloses a CDMA system with time multiplexed Traffic Channels (TCH) and Dedicated Control Channels (DCCH) on layer 2 within every CDMA frame.

OBJECT OF THE INVENTION

[0014] An object of the present invention is to introduce a method for a flexible and dynamic division of radio resources in the base station subsystem of a cellular radio network.

SUMMARY OF THE INVENTION

[0015] The object of the invention is achieved by dividing the radio resources in the base station subsystem - or in a similar arrangement responsible for the division of radio resources - into frames, among which the base station subsystem can allocate, according to the traffic demands of the moment, various sizes of modular, parametrized sections to be used by the different connections. These frames are repeated cyclically so that the repetition sequence contains either a single frame or a group of consecutive frames.

[0016] The invention is characterised in what is said in the characterizing portions of claims 1, 37, 42 and 46.

[0017] In the method of the invention, the so-called physical layer of the transmission channel between a first radio station and a second radio station is divided into frames. The exemplary denominations "base station" and "mobile station" are used to distinguish the radio stations from each other throughout this patent application. Each frame may be further divided into smaller units, the size of which is defined by two coordinates or dimensions, which makes the subdivision of a frame conceptually two-dimensional in structure. The first dimension is time; this means that the frame has a given duration in time, which can be further divided into consecutive time slots. In a preferred embodiment of the invention, each frame contains an equal number of time slots, but the usage of the time slots may vary from one frame to another. The second dimension can be frequency or code. If the second dimension is frequency, there can be extracted, in each time slot contained by the frame, frequency bands that are narrower than the total allocated frequency band covered by the frame. If the second dimension is code, a given number of mutually orthogonal or nearly orthogonal codes is available during each time slot.

[0018] The smallest resource unit to be allocated from one frame is a slot, the size of which is in the first dimension defined by the length of the time slot and in the second dimension by a division unit determined according to the nature of the second dimension. For instance in a time-frequency frame, the size of the slot in the second dimension is the bandwidth of the frequency band employed in each case. One slot is always allocated as a whole to the use of one connection. It is important to notice that in this patent application, a time slot is conceptually a different thing that a slot. A time slot is generally a division unit of a frame in the time dimension. A slot is the unit of physical radio resources that may be allocated to a single connection.

[0019] A certain predetermined number of consecutive frames forms the so-called superframe. Because in digital systems various numbers in general are most naturally powers of two, the superframe advantageously contains 1, 2, 4, 8, 16, 32 or 64 frames. The flexibility and dynamic adaptability of the method according to the invention are both due the fact that the slots contained by a given frame are not necessary equal in size, that the slot structure of the frames contained in the superframe is not necessarily similar, and that it is not necessary to allocate an equal number of slots from a frame or superframe to each connection. The slot structure and the reservation of slots for the use of various connections can change superframe by superframe. On the other hand, if the data transmission need does not change, the first frame in a given superframe has a similar slot structure as the first frame of the preceding superframe, the second frame is similar to the second frame of the preceding superframe, and so forth. The word superframe is naturally only an exemplary denomination to a concept that may represent one or more consecutive frames.

[0020] In an uplink data transmission, i.e transmission that proceeds from the mobile stations to the base station subsystem, the mobile stations need some kind of arrangement by which they can reserve data transmission capacity for use. In a preferred embodiment of the invention, each uplink superframe contains random access slots, during which the mobile stations can freely send packet-shaped capacity requests. Respectively, downlink superframes contain allocation grant slots, where the base station subsystem notifies the granted allocations. Granting takes place on the basis of capacity requests received successfully by the base station subsystem and according to the priority regulations set for different types of connections and the prevailing traffic load. The base station subsystem advantageously maintains a superframe-size reservation table, where it manages the allocations so that the available radio resources are utilised in an optimal fashion.

[0021] In a downlink data transmission the base station subsystem allocates data transmission capacity similarly according to the priority regulations set for different types of connections and the prevailing traffic load. It notifies the downlink allocations preferably in the same paging messages that it uses to inform the mobile stations about incoming downlink transmission requests. Once a mobile station has acknowledged the correct reception of a paging message, the downlink transmission may begin using the allocated transmission capacity.

BRIEF DESCRIPTION OF DRAWINGS

[0022] The invention is described in more detail below, with reference to the preferred embodiments presented as examples and to the appended drawings, where

Figure 1 illustrates a known cell in a cellular system,
Figure 2a illustrates some structural elements of a frame according to the invention,
Figure 2b illustrates a variation of Figure 2b,
Figure 3 illustrates a superframe according to a preferred embodiment of the invention,
Figure 4a illustrates an uplink realtime data transmission according to a preferred embodiment of the invention,
Figure 4b illustrates a timing aspect of the messages of Figure 4a,
Figure 5a illustrates a downlink realtime data transmission according to a preferred embodiment of the invention,
Figure 5b illustrates a timing aspect of the messages of Figure 5a,
Figure 6a illustrates an uplink non-realtime data transmission according to a preferred embodiment of the invention,
Figure 6b illustrates a timing aspect of the messages of Figure 6a,
Figure 7a illustrates a downlink non-realtime data transmission according to a preferred embodiment of the invention, and
Figure 7b illustrates a timing aspect of the messages of Figure 7a,
Figure 8 illustrates a timing aspect of messages in asymmetric trasmission resource sharing according to a preferred embodiment of the invention,
Figure 9 illustrates full TDD operation according to the invention.
Figure 10 illustrates a method according to the invention for regulating the transmission power, and
Figure 11 illustrates an advantageous algorithm for slot allocation.
Figure 12a shows a block diagram of a base station subsystem according to the invention, and
Figure 12b shows a block diagram of a mobile station according to the invention.

[0023] Figure 1 was already referred to above, in the description of the prior art; therefore we shall mainly refer to Figures 2a - 11 in the description of the invention and its preferred embodiments below. Like numbers for like parts are used in the drawings.

DISCUSSION OF PREFERRED EMBODIMENTS

[0024] Figure 2a illustrates a two-dimensional frame 14 according to a preferred embodiment of the invention. In the above description it was maintained that the first dimension of the frame is time and the second dimension can be either time, frequency or code. In the case of Figure 2a, the second dimension of the frame

14 is frequency or time. The [illegible]f the frame in the direction of both dimensions must be chosen so that it is compatible with other specifications set for the system. In this example, the length of the frame in the time direction is about 4.615 milliseconds, and it is divided, in the time direction, into eight time slots, in which case the length of one time slot 15 is about 0.577 ms. The frame width in the frequency direction is about 2 MHz.

[0025] The smallest uniform structural elements of the frame, i.e. the slots, are various subdivisions of a time slot 15. In the lower left portion of Figure 2a, time-frequency division is applied, whereby the chronological length of each slot is the same as that of a time slot, but its width in the frequency direction may be 200 kHz, 1 MHz or 2 MHz. Reference number 16 denotes a large, 0.577 ms x 2 MHz slot, reference number 17 denotes a medium-sized, 0.577 ms x 1 MHz slot, and reference number 18 denotes a small, 0.577 ms x 200 kHz slot. In the lower right portion of the Figure, time-time division is applied, whereby each slot employs the whole 2 MHz bandwidth of the system but its chronological duration may be 1/1, 1/2, or 1/10 of the length of a time slot. Reference number 16 denotes again a large, 0.577 ms x 2 MHz slot, reference number 17 denotes a medium-sized, 0.2885 ms x 2 MHz slot and reference number 18 denotes a small, 0.0577 ms x 2 MHz slot. In those divisions in which five small slots share a time slot with one medium-sized slot (row C: of the division examples), it is naturally possible to present a mirror image alternative (for example a time slot which begins with a medium-sized slot and ends with five small slots).

According to another suggestion, the number of different slot size categories is four, and their relative sizes are such that the slot of the largest size category would correspond to two slots of the second largest size category, four slots of the third largest size category and eight slots of the smallest size category. Also other arrangements for the relative slot sizes are possible.

[0026] A carrier wave solution, where one frame can contain several elements with different widths on the frequency band, is called a parallel multicarrier structure. The base station subsystem may change the frame structure, so that it replaces one large slot by two medium-sized, ten small or one medium-sized plus five small slots or vice versa, or so that it replaces one medium-sized slot by five small slots or vice versa. This property is called the modularity of the frame: a given slot or slot group forms a module (like the group of five small slots 18 on row C: of the division examples), which can in the corresponding time slot contained in some later frame be replaced by a different module (like a single medium-sized slot 17 on row B: of the division examples), so that the rest of the contents of the frame are not changed, and the available bandwidth is always optimally utilised. The invention does not as such limit neither the number of time slots contained in the frame nor the widths of allowed carrier bands, but in order to maintain modularity, it is particularly advantageous that the slots are each other's integral multip[illegible]with respect to their dimensions. For instance three 250 kHz wide slots in time-frequency division could not be modularly replaced by 450 kHz wide slots, but only one 450 kHz slot would fit in the space left by the three narrower slots, and 300 kHz of the bandwidth would remain unused.

[0027] The invention does not require that the frame would occupy a continuous range of frequencies (2 MHz in Figure 2a). It is possible to define a frame so that it covers two or more separate frequency bands. Even a single slot may cover two or more separate frequency bands, which naturally requires the corresponding transceiver to have multiple operation capabilities, i.e. in reception the capability of receiving on at least two different reception frequency bands simultaneously and combining the received information correctly, and in transmission the capability of dividing information into at least two separate transmitter branches and transmitting it simultaneously on at least two different transmission frequency bands.

[0028] Figure 2b illustrates a CDMA alternative to the division of time slots according to Figure 2a. During each time slot 15 there may be a different number of allowed spreading codes, with different spreading ratios. The spreading ratio is a characteristic feature of a spreading code and from the viewpoint of resource sharing it defines how much physical radio resources must be allocated to a single connection. The bigger the spreading ratio of a spreading code used in a connection, the lower the bit rate in that connection, and correspondigly the larger the number of possible simultaneous connections during a given period of time using a given bandwidth. In the example of Figure 2b, three types of spreading codes are available. The Code 1 type spreading codes have such a small spreading ratio R that information that is transmitted with a Code 1 type spreading code fills the capacity of a whole time slot (row A:). The spreading ratio of Code 2 type spreading codes is 2*R (i.e. twice that of Code 1), so two connections using orthogonal or nearly orthogonal Code 2 type spreading codes may exist simultaneously in a single time slot (row B:). The Code 3 type spreading codes have a spreading ratio 10*R (i.e. ten times that of Code 1), so different combinations of orthogonal or nearly orthogonal spreading codes may exist simultaneously; on row C: the time slot accommodates five connections with Code 3 type sreading codes and one with a Code 2 type spreading code, and on row D: there are ten simultaneous connections with Code 3 type spreading codes. A simple comparison between Figures 2a and 2b shows that the time-code division may be interpreted to define slots in a fashion that is analogous to the use of time-frequency or time-time-division.

[0029] Apart from the slot dimensions, the capacity of a slot, i.e. the amount of data that can be transmitted in one slot, depends on the modulation and error protection methods used in the coding of the data, as well as of the rest of the signal structure in the slot. In the time-

frequency arrangement according to Figure 2a, where the allowed bandwidths are 200 kHz, 1 MHz and 2 MHz, it has been found advantageous to use, on the two narrower bandwidths (200 kHz and 1 MHz) a binary-offset QAM (B-O-QAM, Binary Offset Quadrature Amplitude Modulation) and on the widest bandwidth (2 MHz) a quaternary offset QAM (Q-O-QAM, Quaternary Offset Quadrature Amplitude Modulation). Other modulation methods are also possible; they are as such known to the person skilled in the art.

[0030] Figure 3 illustrates a superframe according to a preferred embodiment of the invention. It was already pointed out that the invention does not limit the number of consecutive frames contained in the superframe, but advantageous numbers are powers of two. At its shortest, a superframe may consist of only one frame. In the case of Figure 3, the superframe 19 contains four chronologically consecutive frames 14. Here the frames have consecutive numbers, so that the number of the first frame is described by letter N representing a non-negative integral, the next frame is N + 1, the next N + 2 and the number of the last frame in the superframe is N + 3. The time slots of the frames are also numbered with consecutive non-negative integrals, so that the first time slot in each frame is number 0, and the last time slot is number 7. The drawing also illustrates, by way of example, the division of the slots into payload slots and control data slots. Slots containing payload information, i.e. transmittable data proper, are marked with letter I (Information), and the slots containing control data, i.e. signalling data, are marked with letter C (Control).

[0031] The control data slots form one or several logic control channels, which are available for instance for transmitting messages controlling the starting, maintaining or ending of a connection, for defining the need to change base stations and for exchanging commands and measurements relating to the transmission power and the power-saving mode of the mobile stations between the base station subsystemand the mobile stations. It is advantageous to place the control slots in a certain relatively compact portion of each frame which contains control slots, because this way the rest of the frame may be very flexibly allocated in different modular slot combinations. If the control slots would be scattered all over the frame structure, only a limited selection of allocatable slots would fit between them.

[0032] According to the preferred embodiment of the invention, the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) maintains a parametrized reservation table, which indicates the size and state of occupancy of each slot, as well as other possible parameters concerning the slot. Changes in the slot structure of the frames 14 and/or in the allocation of slots for the use of given connections take place in between the superframes, i.e. the reservation table remains valid for the duration of one superframe at a time. In order to ensure an optimal operation, the base station subsystem must have a reservation table routine, which maintains the reservation table according to given evaluation criteria. Among such important criteria that the reservation table routine takes into consideration before granting access to a new connection are for instance the traffic load, the type of information contained in the new connection (for example speech, video, data), the priority defined on the basis of the new connection (for example ordinary call, emergency call), the general power level of the traffic load as well as the type of the data transmission connection (for example realtime, non-realtime). Moreover, it is possible to define more sophisticated criteria, such as the susceptibility to interference of a given slot, and the transmission power required by the slot.

If a certain base station takes into consideration the reservation tables of the surrounding base stations, too, it may in its own reservation table allocate the slots according to the power level and switching type of the connection. The former means that mobile stations applying a high power level and a low power level have their own allocated slots, which are located in the reservation tables of adjacent base stations, in optimal locations with respect to the total interference of the system. The latter means that circuit-switched and packet-switched connections have their own slots located in the reservation tables of adjacent base stations in optimal locations with respect to the total interference of the system. Optimality is defined so that all users suffer as little as possible from the noise signals of other users. If the slots are allocated for instance according to the power level, the first base station grants low-power users (those located near the first base station) such slots, during which in the second base station there is a connection of a high-power user (one located far from the second base station).

[0033] Previously known slot allocation methods are usually sequential (of 8 available slots, for example slot number 0 is allocated first, then slot 1 and so on; or slot number 0 is allocated first, then slots 2, 4, and 6 in this order, then slots 1, 3, 5, and 7) or random. In connection with the present invention it has been found advantageous to use a slot allocation method that takes into consideration the different evaluation parameters that may be presented to describe each slot. The base station subsystem may measure the level of noise in each slot and arrange the free and allocatable slots according to their quality, i.e. noise level. If a new slot request indicates that the desired new connection should have very tight realtime requirements with only limited retransmission possibilities, the base station subsystem will give it a very high-quality slot with low noise levels. A non-realtime connection with good retransmission tolerance could get a lower-quality slot, in order to keep the best slots free for possible future realtime connection requests. The size of a slot is important: if there are both small and large slots free and available in a frame, and a new slot request indicates only a small need of resources, it is advisable to allocate an existing small slot for it even if it could get a better quality slot through re-

placement of a larger slot wi[illegible]roup of smaller slots in a modular fashion and allocation of one of those.

[0034] The representation of the slot allocation method in the base station subsystem may be an allocation equation or a logical algorithm (conclusion chain). The former means that the base station gives different calculational weights to the relevant factors in consideration (noise level, realtime service requirements, need for splitting of large slots, estimated power level, etc.) and calculates a result that points at a certain slot. The latter means that the base station subsystem maintains a set of candidate slots and evaluates them one at a time to find out which one would suit best to the newly requested connection. Figure 11 illustrates an exemplary logical algorithm that the base station subsystem may use to determine, which slot it will allocate to a given new connection. Operation begins with a slot request 100 which may come either from the network side (downlink slot request) or from the mobile station's side (uplink slot request). In block 101 the base station subsystem checks, which frame storage (uplink or downlink) it should choose. The actual selection of a storage (reservation table) is done as a background process in blocks 102, 103, and 104, and the algorithm proceeds to block 106. Here a frame selection process 107, 108, 109 similar to the frame storage selection is initiated. In the Figure we suppose that each superframe consists of two frames.

[0035] In block 110 the base station subsystem starts the evaluation process from the time slot that has the lowest fragmentation value, i.e. that contains the largest slots. In block 111 it rejects all timeslots where the new connection would result in multicarrier allocation. In block 112 it checks, whether there are any other factors that would prevent the use of the time slot (too small slot capacity, preset transmission power limitations, unacceptably high noise levels etc.) and if not, it updates the set of candidate time slots. Block 114 causes a repetition of steps 110, 111, 112, 113, and potentially 105 until all timeslots have been scanned. In block 115 the base station finds the best candidate time slot by applying certain radio resource management rules and selection criteria. There may be for example two best candidates with equally low.interference, and the base station subsystem must examine, whether the estimated power requirement for the new connection agrees with certain preset power and noise limitations in each slot and whether choosing of any of the best candidates would imply calculational penalty in the form or splitting a large slot into smaller ones.

[0036] After having made the selection in block 115, the base station subsystem additionally checks in block 116, whether the calculated quality estimates 117 indicate a sufficiently high transmission quality. Normally the procedure continues to block 118, but it may happen that evan the best candidate slot will not offer enough quality. In such cases the base station subsystem branches into block 119, where it initiates a possible operation mode change to enhance the transmission quality. The procedure en[illegible] a slot assignment decision 120.

[0037] In the method according to the invention, the sharing of radio resources takes place in similar fashion both as regards realtime and non-realtime services: the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) allocates slots for each service according to their needs. Similar control messages and mechanisms regulate the distribution of radio resources in both cases; only the detailed content of the control messages and some principles of allocation and deallocation are somewhat different depending on the type of service in question. Data transmission over radio path during an already created connection is somewhat different depending on whether the service in question is realtime or non-realtime. Applications requiring realtime or nearly realtime service are for instance speech transmission in packets and the video connection required by a videophone. In a simulation of the method according to the invention it was presupposed that in the transmission of speech, in between the base station subsystemand the mobile station there is achieved a bit error ratio (BER) 10^{-3}, when the longest allowed data transmission delay is 30 ms. In a video connection required by a videophone, the corresponding values are 10^{-6} and 100 ms, where the longer delay is caused by the time interleaving of the transmitted data. These services apply a forward error correction (FEC) type error correction and a radio resource reservation protocol to be explained in more detail below. A non-realtime service is for instance file transmission in an ordinary Internet connection. It applies packet-type data transmission and an ARQ-type error correction protocol (automatic repeat on request).

[0038] We shall next observe realtime uplink data transmission in an ordinary case, with reference to Figures 4a and 4b. The arrows of the Figure 4a represent data transmission between a base station (BS) and a mobile station (MS) in chronological order so that time in the drawing passes from top to bottom. Certain superframes transmitted by the base station contain so-called Y slots, where the base station notifies when in the uplink direction there are next found PRA (packet random access) slots, i.e. such points in the uplink superframe where the mobile stations can send capacity requests. Arrow 20 represents the data transmitted in an Y slot of a given downlink superframe concerning the location of the next PRA slots. If the PRA slots would have a constant location in each uplink frame or superframe, the base station would not need to announce their location in an Y slot, but it adds flexibility to the system to reserve the base station subsystem the possibility of placing the PRA slots in the most suitable way and to change their location between superframes.

[0039] In one of the successive PRA slots the mobile station transmits, according to arrow 21, a PRA message where it identifies itself and informs what type of connection is requested (realtime, coding, slot type etc.

factors). Because there is no coordination whatsoever between different mobile stations, it may happen that several mobile stations transmit a PRA message simultaneously. In that case one at the most is received. However, in Figure 4a it is assumed that the PRA message according to arrow 21 is received, in which case in the PAG (packet access grant) slot of the next downlink frame the base station notifies, according to arrow 22, that a given uplink slot or slots are granted for the mobile station. At the same time it informs the location of the granted slot (slots) in the uplink superframe. In the packet access protocols of the prior art the requesting station generally obtains as its radio resource that time slot or other corresponding resource point where it transmitted a successful capacity request. According to the present invention, the slot (or slots) allocated to the connection can be located anywhere within the scope of the next uplink superframes.

[0040] When the mobile station has received information of the granted radio resources, it starts data transmission according to arrow 23. During the connection there may arise a situation where the mobile station wants to increase the amount of radio resources it has available. In that case it reserves further slots according to arrow 24, by means of the same procedure that was explained above, i.e. by transmitting a capacity request where it indicates what size and type the new slot should be. It may also happen that during the connection, the data transmission demand of the mobile station decreases, and it wishes to reduce the employed radio resources. Now it ends transmission in given slots according to arrow 25, in which case the base station can allocate the released slots to the use of other connections. Arrow 26 represents a message whereby the mobile station ends transmission.

[0041] Figure 4b serves to clarify the relation of some the above-mentioned messages to the frame and superframe timing. Here we assume that there are two frames 14 in each superframe 19. We further assume that the downlink (DL) direction transmission occurs simultaneously with the corresponding uplink (UL) direction transmission, the two being separated from each other through for example Frequency Division Duplexing (FDD), i.e. placing them on different frequency bands. Still further, we assume that in the middle of each frame 14 there is a range of control slots that appear shaded in Figure 4b. It is advantageous to place the control slot ranges coincidentally in time in both downlink and uplink directions, because it will prevent the loss of important control information due to simultaneous traffic transmission. Taken the other way raound, it will also prevent the loss of any traffic transmission opportunities due to control information reading. The chronological order of the frames in Figure 4b is from left to right.

[0042] The mobile station listens to the downlink transmission DL and finds the slot addresses of the next available PRA slots in a message that the base station transmits in a Y slot. These available PRA slots are situated in the second frame of the leftmost superframe in Figure 4b. The dashed line represents a logical connection between the slots, in other words it shows that in the Figure the message sent in a certain Y slot governs the use of the PRA slots in the following complete UL frame. The mobile station uses a PRA slot to transmit a PRA message to the base station. Taken that the attempt is succesful, the base station transmits a PAG message in a PAG slot of the next complete DL frame. The PAG message tells the mobile station to use a certain slot (or certain slots) RT from the next complete UL frame for the desired transmission carrying real time traffic. The dashed lines from the PAG slot to the next complete UL frame show that the granted UL slot may be anywhere in the frame. The transmission continues in the same slot until the data source is exhausted or the base stations sends a separate *RT* uplink channel update command (not shown in Figure 4b).

[0043] A downlink realtime data transmission takes place according to Figures 5a and 5b. A separate slot capacity request is not needed, because the base station subsystem itself maintains the reservation table for the slots and is thus able to direct downlink data transmission to a suitable slot. The message that tells the location of the chosen slot(s) to the mobile station can be transmitted to the mobile station through packet paging (PP) channels, at least one of which is read by each active mobile station. The repetition of the PP message in the packet paging channel, illustrated by arrows 27 and 28, means that the base station transmits a PP message until the mobile station answers (or until a given time limit is surpassed). The mobile station that has received the transmitted PP message echoes, according to arrow 29, the PP message back to the base station as a packet paging acknowledgement (PPA). The base station starts transmission 30 after receiving, intermediated by the PPA, confirmation that the call was received. The resource demands of downlink data transmission can also change during the connection, in which case the base station subsystem allocates more slots to the connection (when resource demand grows) 31 or releases part of the slots (when resource demand decreases) 32. Notification of the changes is transmitted to the mobile station advantageously through packet paging. Arrow 33 illustrates the ending of the transmission.

Figure 5b clarifies the relation of PP and PPA messages and downlink realtime data transmissions to the frame and superframe timing in an embodiment where we again assume simultaneous FDD uplink and downlink transmission with two frames 14 per superframe 19. After the base station has transmitted a PP message, the first acknowledging chance for the mobile station is in the PPA slots of the next complete UL frame. After receiving the PPA acknowledgement message the base station may start the realtime DL data transmission in the next complete DL frame. It continues the realtime DL data transmission in the same slot in each following

DL superframe, until the data [illegible]e becomes exhausted (exhaustion not illustrated in the Figure), which the mobile station detects when it finds that the slot is empty.

[0044] Several simultaneous connections requiring realtime service may exist, in between a given mobile station and base station, both in the uplink and downlink direction. Simultaneous connections are also called parallel connections. According to a preferred embodiment, the mobile station has a given temporary logic identifier which distinguishes it among other mobile stations communicating with the same base station subsystem. The length of this identifier can be for instance 12 bits. In order to distinguish between parallel connections, there may be used a short (for instance 2-bit) additional identifier. When the mobile station wishes, during a given connection, to start a parallel realtime connection, it sends the base station subsystem a capacity request where it notifies its temporary logic identifier as well as its additional identifier with a value different than the value of the additional identifier describing the preceding ongoing realtime connection. Respectively, the base station subsystem may start a new downlink parallel, realtime connection by transmitting a PP message where it includes the logic identifier of the mobile station for which the message is intended, plus an additional identifier with a value different than the values of additional identifiers describing already ongoing realtime connections. On the basis of the additional identifier, each receiving station knows whether the transmitting station wishes to increase the capacity of some ongoing realtime connection or to start a new parallel connection.

[0045] Figures 6a and 6b illustrate a non-realtime uplink data transmission in a normal case. Arrow 34 corresponds to arrow 20 in Figure 4a, i.e. it represents the data concerning the location of the next PRA slots transmitted in the Y slot of a given downlink superframe. In one of the successive PRA slots, the mobile station transmits, according to arrow 35, a PRA message where it identifies itself and notifies how much non-realtime data it wishes to transmit. The amount of data can be given for instance in bytes. In the next PAG slot, the base station notifies, according to arrow 36, what is the location of the control slot reserved as the uplink-direction control channel in the downlink superframe. In the next control slot, the base station transmits, according to arrow 37, the locations in the uplink superframe of the first slots reserved for the connection. In these slots, the mobile station transmits uplink data according to arrow 38. The uplink slots are grouped for instance so that 16 slots form a group. A control message according to arrow 37 has transmitted for the mobile station information of the location of these 16 slots. When the mobile station has transmitted 16 slotted messages, it receives, according to arrow 39, in the next control slot from the base station subsystem a response, where the base station informs how the data was received in the slots of the first group. If the base station has found fault in some slots, the mobile station must retransmit the data contained in these slots. The control mes[illegible] illustrated by arrow 39 also contains information of the location of the slots belonging to the next group, in which case uplink transmission continues in these slots according to arrow 40. Transmission ends when the mobile station has transmitted all of the desired information.

[0046] In the above cases, the realtime service of Figure 4a, and in the non-realtime service of Figure 6a, the interpretation of the reservation message is different. In the realtime service, there is reserved a given radio resource (slot) for continuous use from consecutive superframes. This means the same as the reservation of a given transmission rate (x bits/s) for the use of the connection. In the case of a non-realtime service, the resources are reserved for the transmission of a given amount of bits or bytes, in which case the data transmission rate need not be constant. If there are a lot of radio resources available, the base station subsystem may, in the control messages represented by arrows 37 and 39, grant for the mobile station slots that are very near to each other. If the rest of the traffic load of the base station is heavy, or if it grows during the non-realtime connection, each superframe contains less free slots, and the control messages described by arrows 37 and 39 grant for the mobile station slots that are located further away from each other in the data flow.

[0047] Figure 6b illustrates the timing in the setup phase of a non-realtime uplink connection. The graphical conventions are the same as in Figures 4b and 5b. The operation begins when the mobile station finds the slot address of the next available PRA slot(s) in a message that was transmitted in a Y slot from the base station. The mobile station sends a PRA message, which is here supposed to reach the base station at the first attempt. In the next complete downlink frame containing PAG slot(s) the base station sends a PAG message that identifies an NRT control slot (NC) from the following superframe. In the first NC slot the base station transmits a message in which it gives an address for a downlink ARQ slot as well as the addresses for the first granted uplink NRT traffic slots. The first one(s) of the granted uplink NRT traffic slots may be in the next complete uplink frame at earliest. The mobile station starts transmission in the allocated NRT traffic slots and the base station acknowledges the transmissions with ARQ messages and grants further uplink NRT traffic slots in the following NC slots. This continues until the total amount of uplink NRT data has been sent.

[0048] A downlink non-realtime data transmission differs from what was explained above and is illustrated in Figures 7a and 7b. When the base station subsystem wishes to transmit non-realtime data for the mobile station, it first transmits, according to arrow 41, a PP message containing information of the location of the slot or slots reserved to an uplink acknowledgement channel in uplink superframes, as well as of the location of the first slots reserved for the data to be transmitted in the downlink superframes. Arrow 42 illustrates the retrans-

mission of the same PP mess[illegible] When the mobile station notifies in a PPA message according to arrow 43 that it is ready for reception, the base station subsystem transmits the data in the previously informed slots according to arrow 44. The mobile station sends a positive or negative ARQ response 45 of the received data, which response may also contain measuring results used for downlink power regulation or similar information. If the location or amount of the downlink slots is changed, the base station subsystem notifies the mobile station to that effect, according to arrow 46. The transmission ends when the base station subsystem has transmitted all of the desired data and received a positive response. Naturally the transmission may end prematurely, if interference cuts the connection or the mobile station moves to an area covered by some other base station.

[0049] In Figure 7b the downlink non-realtime transmission starts with a PP message sent by the base station in a PP slot of a certain downlink frame. The mobile station responds by sending, in a PPA slot identified in the PP message, a PPA message and optionally an empty ARQ message in the corresponding slot that was also identified in the PP message. The first downlink transmission will occur at earliest in the next complete downlink frame following the frame during which the base station received the mobile station's PPA message. The mobile station acknowledges the downlink NRT transmission in its ARQ replies and the process continues until the non-realtime downlink data source has been exhausted (not shown in the Figure).

[0050] In non-realtime connections there can be applied the same principle of parallel connections that was explained above, in the description of realtime services. However, because the radio resource control method according to the invention aims at a situation where up to all otherwise free slots can be temporarily allocated to a given non-realtime connection, the concept of parallel connections is not as important for non-realtime services as it is for realtime services. In the case of non-realtime services, a non-realtime data transmission task can generally be finished before starting the next.

[0051] The invention does not require that the radio transmission capacities in uplink and downlink transmission should be equal as suggested by the graphical layout of Figures 4b, 5b, 6b and 7b. On the contrary, the invention allows the base station subsystem (or a corresponding arrangement responsible for the division of radio resources) to allocate slots from the uplink frames for downlink traffic or vice versa. For example in teleshopping, electronic newspaper services and WWW (World Wide Web) browsing the need for downlink capacity is far greater that the need for uplink capacity, which could result in unbalanced resource usage if the system capacities in uplink and downlink could not be made asymmetrical dynamically.

[0052] When the slot allocation routine has decided to allocate an uplink slot to downlink traffic the base station subsystem simpl[illegible] the mobile station in a PP message that the slot it should receive is in uplink domain (for example, on uplink frequency) instead of the usual downlink. In the opposite situation, in which a downlink slot is allocated for uplink transmission, a PAG message (in realtime services) or an NC message (in non-realtime services) from the base station subsystem allows the mobile station to use a certain nominally downlink slot or slots for its uplink transmission. It has to be noted, however, that changing the transmission direction in the middle of a superframe requires a guard interval in between, the length of which is equal to two times the maximum propagation delay in the cell. It is therefore advisable to group the slots into compact blocks that contain only slots in one and the same transmission direction, in order not to waste time in multiple consecutive transmission direction changes. If the coverage area of a certain base station is so small that the length of the guard interval is negligible, this restriction may be somewhat relieved.

[0053] Figure 8 illustrates the exchange of transmissions on the downlink frequency band DL and uplink frequency band UL when some uplink transmission capacity is reserved for realtime downlink use. The graphical conventions are the same as in Figures 4b, 5b, 6b and 7b, except that an additional crossed hatch now denotes a portion of the frames received for downlink use and an inclined hatch denotes a portion of the frames received for uplink use. During the first superframe period the base station transmits in a Y slot Y1 a message that tells the mobile station the location of PRA slots PRA1 in the next complete uplink frame. The mobile station uses the PRA opportunity to transmit a PRA message that reaches the base station and results in a PAG message PAG1 in the next complete downlink frame. The PAG message allocates a slot T1UL (or a group of slots) to the mobile station. From that moment on until the exhaustion of the uplink realtime data source (not shown in the Figure) the mobile station uses this allocation regularly in each superframe to transmit its realtime data.

[0054] In the second frame of the second superframe the base station transmits a PP message PP2 indicating its willingness to transmit realtime downlink data to the mobile station. The PP message PP2 identifies a slot (or a group of slots) T2DL from the second frame in each following uplink superframe. The mobile station transmits its PPA answer PPA2 in the next complete uplink frame, after which the base station starts using the identified (cross-hatched) portion T2DL of the uplink superframes for a downlink realtime transmission. The uplink frequency band UL is now effectively time-division duplexed (TDD). When the downlink transmission using the slot T2DL ends (not shown in the Figure), the uplink frequency band may return to a purely uplink state or the base station subsystem may allocate uplink capacity to another downlink transmission. Naturally there may be a multitude of simultaneous uplink and downlink connections in use, in the setup phase, or in the tear-down

phase, but for graphical clarity these are not shown in the Figures.

[0055] Next we shall consider some further duplexing aspects. One alternative is to arrange the uplink and downlink transmission in each cell according to time division duplex (TDD). In that case the transmission is not chronologically continuous in either of the directions, but transmissions in the two directions alternate on a frame basis during each superframe. Only one frequency band, common for both the uplink and downlink directions, is needed in the cell. If the users use a radio connection controlled according to the method of the present invention for browsing the www (World Wide Web) or for another similar purpose, where the data transmission need in one direction is manifold compared to the other direction (in www-browsing the volume of the downlink data transmission is 7 - 15 times the volume of the uplink data transmission), the time division duplex can be arranged so that in each superframe, X consecutive downlink frames are followed by Y consecutive uplink frames (or Y consecutive uplink frames are followed by X consecutive downlink frames), where the relation of the integrals X and Y is X > Y. Still further, the cross-allocation scheme explained previously may be introduced so that even if there is a predetermined (fixed or dynamically changing) number of frames for each transmission direction, the base station subsystem may allocate downlink slots for uplink transmissions or vice versa.

[0056] Figure 9 illustrates the exchange of transmissions in fully time-division duplexed operation with all four possible combinations of uplink, downlink, realtime and non-realtime. Each row in the Figure represents a single frequency band that is used (here: symmetrically) for both uplink and downlink transmission. A superframe 19 consists of two frames 14, the first of which is for downlink (DL) and the second is uplink (UL). The shaded portion of each frame contains control slots. On the top row (Uplink RT) the mobile stations finds in a Y slot downlink transmission the slot addresses of the next available PRA slots, which are in the uplink frame of the same superframe. It transmits a PRA message and receives in the next downlink frame a PAG message allocating a slot from the uplink frame. Thereafter the mobile station uses this regularly occurring slot for uplink realtime transmission. On the second row (Downlink RT) the base station transmits a PP message that identifies a downlink information slot from the next complete downlink frame on. The mobile station responds with a PPA message, whereafter the downlink realtime transmission commences.

[0057] On the third row (Uplink NRT) of Figure 9, the mobile station transmits a PRA message after having found a correct PRA slot address in a received Y slot message. In the downlink frame of the next superframe the base station sends a PAG message that identifies an NRT control slot (NC) from the downlink frame of the third superframe. In the first NC slot the base station then transmits a message in which it gives an address for a downlink ARQ slot as well as the addresses for the first granted uplink NRT traffic slots. The first one(s) of the granted uplink NRT traffic slots may be in the uplink frame of the same superframe at earliest. The mobile station starts transmission in the allocated NRT traffic slots and the base station acknowledges the transmissions with ARQ messages and grants further uplink NRT traffic slots in the following NC slots. On the last row (Downlink NRT) the downlink non-realtime transmission starts with a PP message sent by the base station in a PP slot. The mobile station responds by sending, in a PPA slot identified in the PP message, a PPA message and optionally an empty ARQ message in the corresponding slot that was also identified in the PP message. The first downlink transmission will occur at earliest in the downlink frame of the next superframe. The mobile station acknowledges the downlink NRT transmission in its ARQ replies and the process continues until the non-realtime downlink data source has been exhausted (not shown in the Figure).

[0058] The radio resources control method according to the invention also offers a possibility for regulating the transmission power during radio connection. Above we referred to the fact that the control slots contained in the superframes form one or several logic control channels. One two-way logic channel per connection can be called a SCCH channel (system control channel), which in a preferred embodiment of the invention comprises, per each active connection, one slot (in the above given time-frequency space example one 200 kHz slot) per sixteen superframes both in the uplink and downlink directions. The SCCH channel is used for the whole duration of the active data transmission period, and it can be employed for instance for transmitting measurements relating to the power level, for arranging the mutual timing of the base station subsystem and the mobile station, for transmitting information relating to a handover to a different base station and for transmitting commands directed from the base station subsystem to the mobile station. The base station subsystem may for instance command the mobile station into a so-called sleep mode, where the mobile station is inactive for a predetermined period of time in order to save power.

[0059] Another possibility offered by the method according to the invention for regulating the power level of mobile stations is a public power control channel (PPCC) independent of the slot division in the frames. In order to realise it, each downlink frame comprises a given PPCC slot containing a given amount of power control bits per each possible slot in the corresponding uplink frame. The amount of power control bits in the PPCC slot can be chosen so that if the respective frame would be altogether composed of the smallest possible slots, each slot would have its own bits. When the frame in practice contains larger slots, too, in the controlling of each larger slot there are used all those bits of the PPCC slot that refer to the area of the larger slot. This arrange-

ment is illustrated in Figure 1[illegible] PPCC slot 47 comprises the first power control bits 48 and the second power control bits 49. If the corresponding uplink frame 50 would comprise only small slots 51 and 52, the first power control bits 48 would control the first slot 51 and the second power control bits 49 would control the second slot 52. If the small slots in the uplink frame are modularly replaced by a larger slot 53, the power control bits 48 and 49 control the same slot 53, which brings either more resolution or redundance to the control. Thus the structure of the PPCC slot can be independent of the slot structure of the frames in the uplink channel. A similar control channel structure and principle can also be applied in other types of radio resource control connected to the superframe. For example, the point of time of the transmission of each slot can be controlled by a similar procedure.

[0060] The slot allocation principles that were presented previously may be applied also to the existing TDMA systems like the GSM system or the IS-136 system to increase the data transmission capacity of a given radio connection. The size of an allocated slot in a single frequency band will come bigger in the chronological direction if several consecutive slots of each cyclically repeated frame are given to a single connection. Alternatively or additionally the connection may get slots from both uplink and downlink frames, without the limitation that uplink frame slots should be for uplink use only and downlink frame slots for downlink use only. This means that the newly allocated larger slot would actually consist of at least two separate areas in the time-frequency space, with a forbidden separator frequency band separating the nominal "uplink" and "downlink" frequencies in a manner known as such from prior art.

[0061] Figure 12a shows a block diagram of a base station subsystem BSS according to the invention. The functions of the BSS are controlled by a microcontroller 200. The microcontroller 200 is in contact with a slot allocator 201, which performs the slot allocation according to calculations and/or an algorithm. Data of the different slots are stored as a a slot reservation table 202 in a memory. The table includes a list of uplink slots 202a and downlink slots 202b indicating size and state of each slot as well as any other possible parameters and which mobile station a slot is allocated to. According to the slot allocation information received from the slot allocator 201 the microcontroller controls the transceiver 203 of the BSS to function in transmission and reception according to the allocation. The transceiver 203 may include a packet former/deformer 205 for forming a data packet for transmission, whereafter a code adder 206 adds a code if code is one of the dimensions of the slot. A modulator 207 and a RF transmitter 208 modulate the signal to radio frequency and form the carrier signal which is then transmitted by the antenna 204. Accordingly blocks 205 - 208 form a slot under control of the microcontroller 200 in accordance with the slot allocation. In reception blocks 205 - 208 perform the reverse functions under con[illegible]f the microcontroller 200. Blocks 200 - 202 may be part of the base station controller BSC or they may be included in the base station BTS. Blocks 203 - 204 are part of the base station BTS.

[0062] Figure 12b shows a block diagram of a mobile station subsystem MS according to the invention. The functions of the MS are controlled by a microcontroller 300. The microcontroller 300 is in contact with a slot table 301, which stores information about the slots allocated for the mobile station by the base station. The table includes a list of uplink slot(s) and downlink slot(s) indicating size as well as any other possible parameters. According to the slot table 301 the microcontroller controls the transceiver 303 of the MS to function in transmission and reception according to slot table. The transceiver 303 may include a packet former/deformer 305 for forming a data packet for transmission, whereafter a code adder 306 adds a code if code is one of the dimensions of the slot. A modulator 307 and a RF transmitter 308 modulate the signal to radio frequency and form the carrier signal which is then transmitted by the antenna 304. Accordingly blocks 305 - 308 form a slot under control of the microcontroller 300 in accordance with the slot table. In reception blocks 305 - 308 perform the reverse functions under control of the microcontroller 300.

[0063] In the specification above, we have described a method for controlling radio resources with reference to a few preferred embodiments. It is obvious for a man skilled in the art that the explained examples are not meant to be restrictive, but the invention can, according to ordinary professional skills, be modified within the scope of the appended patent claims.

Claims

1. A method for controlling physical radio resources in a radio system comprising a base station subsystem and several mobile stations in radio connection thereto, **characterised in that** the physical radio resources are divided into chronologically consecutive frames (14), said frames containing two-dimensional slots (16, 17, 18) having varying data transmission capacities, in which case

   - the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
   - each slot represents a given share of the physical resources contained in the frame,
   - a multitude of slots in at least one frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
   - the first dimension of the slots is time and the second dimension of the slots is one of the following: frequency, code;

and the base station subsystem makes a decision of allocating the slots for the radio connections on the basis of

- the data transmission needs of the radio connections,
- the changes in the data transmission needs of the radio connections occuring during the radio connections, and
- the size and state of occupancy of the slots.

2. A method according to claim 1, **characterised in that** the slots contained in the frame belong, according to the volume of the respective physical radio resources, to at least two different allowed size categories, and that in order to change the slot structure of a frame, a predetermined integral number of the slots of the first size category can be replaced by a predetermined integral number of the slots of the second size category.

3. A method according to claim 2, **characterised in that** the amount of allowed size categories is three, in which case the slot (16) of the largest size category is equal to two slots (17) of the next largest size category or to ten slots (18) of the smallest size category.

4. A method according to claim 2, **characterised in that** the amount of allowed size categories is four, in which case the slot of the largest size category is equal to two slots of the next largest size category, four slots of the third largest size category or eight slots of the smallest size category.

5. A method according to claim 1, **characterised in that** each frame is divided, in the direction of the first dimension, to a predetermined amount of time slots (15), and each time slot is further divided into slots.

6. A method according to claim 5, **characterised in that** each slot occupies the whole frequency range of the corresponding time slot but the length of each slot in the time dimension depends on its data transmission capacity.

7. A method according to claim 5, **characterized in that** time-frequency division is applied, whereby each slot occupies the whole chronological duration of the corresponding time slot but the width of each slot in the frequency dimension depends on its data transmission capacity.

8. A method according to claim 5, **characterized in that** time-code division is applied, whereby each slot occupies the whole chronological duration of the corresponding time slot but the data transmission capacity of each slot depends on the corresponding spreading code.

9. A method according to claim 1, **characterised in that** a predetermined non-negative integral number of consecutive frames forms a superframe (19), so that in consecutive superframes, such frames that are located in similar positions when starting from the beginning of the superframe correspond to each other with respect to the slot division, if changes have not occurred in the data transmission need of the radio connections in between the superframes.

10. A method according to claim 9, **characterised in that** each superframe contains both slots (I) meant for transmission of information and control slots (C) for realising logic control channels.

11. A method according to claim 10, **characterised in that** a downlink signal comprises a general logic control channel (47) provided for the signalling connected to slotwise radio resource control.

12. A method according to claim 10, **characterised in that** each control slot (C) belongs, according to the physical radio resources represented thereby, to one of the allowed size categories.

13. A method according to claim 1, **characterised in that** a predetermined frequency band is used to convoy both downlink slots and uplink slots according to a time-division duplexing scheme.

14. A method according to claim 13, **characterised in that** a predetermined non-negative integral number of consecutive frames forms a superframe (19) and each superframe contains a first number of downlink frames and a second number of uplink frames.

15. A method according to claim 13, **characterised in that** a predetermined first frequency band is used to convoy nominally downlink slots and a predetermined second frequency band is used to convoy nominally uplink slots, but in response to unsymmetrical traffic conditions in uplink and downlink direction, slots are cross-allocated so that nominally downlink slots are used to convoy uplink traffic or nominally uplink slots are used to convoy downlink traffic.

16. A method according to claim 1, **characterised in that** the base station subsystem maintains a reservation table in order to indicate the size and state of occupancy of the slots in the frames and in order to maintain an optimal rate of usage.

17. A method according to claim 16, **characterised in that** the base station subsystem evaluates the qual-

ity of at least one allocat[illegible]slot and makes a decision of allocating or non-allocating said slot to a connection on the basis of the transmission quality required by said connection.

18. A method according to claim 16, **characterised in that** it comprises in the base station subsystem the steps in which, as a response to a slot request,

- either uplink or downlink reservation table is chosen,
- a reservation table is chosen,
- a set of candidate time slots from the chosen reservation table is formed,
- a set of predetermined selection criteria is applied to find the best candidate time slot,
- the transmission quality offered by the selected best candidate time slot is checked and
- a decision to allocate a slot from the best candidate time slot is made.

19. A method according to claim 16, **characterised in that** the base station subsystem makes a decision of allocating the slots for the radio connections also on the basis on the information contained in the reservation tables of neighbouring base station subsystems.

20. A method according to claim 19, **characterised in that** the base station subsystem allocates slots on the basis of the transmission power used for communication by different mobile stations, so that a first mobile station that uses low transmission power to communicate with a first base station will be allocated a slot that coincides chronologically with a slot allocated to a second mobile station that uses high transmission power to communicate with a second base station.

21. A method according to claim 19, **characterised in that** the base station subsystem allocates slots on the basis of the communication type used by different mobile stations, so that circuit-switched and packet-switched connections have their own slots located in the reservation tables of adjacent base stations in optimal locations with respect to the total interference of the system.

22. A method according to claim 1, **characterised in that** for setting up an uplink radio connection between the base station subsystem and the mobile station the method comprises the steps of

- transmitting from the mobile station, in an allowed uplink capacity request slot, a capacity request (21, 35), where the mobile station indicates the amount of physical radio resources required by the radio connection, and
- making an al[illegible]on decision in the base station subsystem as a response to said capacity request.

23. A method according to claim 22, **characterised in that** the location and amount of the allowed uplink capacity request slots in relation to the frame structure is not constant and the base station subsystem transmits, in a predetermined downlink slot, an announcement indicating the location and amount of the allowed uplink capacity request slots.

24. A method according to claim 22, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised in that** in order to reserve radio resources for the use of a radio connection for uplink realtime data transmission services, the mobile station indicates in its capacity request (21) the required data transmission capacity.

25. A method according to claim 24, **characterised in that** the mobile station additionally indicates in its capacity request a predetermined set of parameters describing the required qualities of the radio connection.

26. A method according to claim 24, **characterised in that** when the data transmission capacity demand grows during an ongoing radio connection for uplink realtime data transmission services, the mobile station sends the base station subsystem a capacity request (24), where it indicates the required additional data transmission capacity.

27. A method according to claim 24, **characterised in that** when the data transmission capacity demand diminishes during an ongoing radio connection for uplink realtime data transmission services having several allocated slots, the mobile station leaves at least one of the allocated slots unused.

28. A method according to claim 24, **characterised in that** each mobile station has a certain temporary logic identifier in order to distinguish the mobile station from other mobile stations operating under the same base station subsystem, and in order to reserve radio resources for the use of a radio connection for parallel uplink realtime data transmission services, the mobile station sends the base station subsystem a capacity request where it indicates

- its temporary logic identifier
- the required parallel data transmission capacity, and
- an additional identifier, which distinguishes the parallel radio connection from other ongoing radio connections convoying realtime data trans-

mission services.

29. A method according to claim 22, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised in that** in order to reserve radio resources for the use of a radio connection for uplink non-realtime data transmission services, the mobile station indicates in its capacity request (21) the amount of data to be transmitted.

30. A method according to claim 22, **characterised in that** in its allocation decision the base station subsystem has the freedom of directing the required radio connection into any available slot and after the allocation decision the base station subsystem transmits to the mobile station in a predetermined downlink access granting slot an indication of the granted slot or slots.

31. A method according to claim 1, **characterised in that** for setting up a downlink radio connection between the base station subsystem and the mobile station the method comprises the steps of

- making an allocation decision in the base station subsystem as a response to the detected need of a new downlink radio connection indicating the amount of physical radio resources required by the radio connection,
- transmitting from the base station subsystem to the mobile station a paging message (27, 28, 41, 42), that announces the location of the downlink slot or slots allocated to the radio connection in said allocation decision,
- as a response to a detected paging message, transmitting from the mobile station a paging acknowledgement message and
- as a response to a detected paging acknowledgement message, commencing downlink transmission from the base station subsystem.

32. A method according to claim 31, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised in that** in order to form a radio connection for downlink realtime data transmission services, the base station subsystem indicates in the paging message (27, 28), for the regularly repeated slots allocated to the radio connection, their location in relation to the frame structure.

33. A method according to claim 32, **characterised in that** when the data transmission capacity demand grows during an ongoing radio connection for downlink realtime data transmission services, the base station subsystem makes an additional slot allocation decision and sends the mobile station a paging message (27, 28, 41, 42), that announces the location of the additional downlink slot or slots allocated to the radio connection.

34. A method according to claim 32, **characterised in that** when the data transmission capacity demand diminishes during an ongoing radio connection for downlink realtime data transmission services having several allocated slots, the base station makes a slot deallocation decision concening at least one of the allocated slots and leaves the corresponding slots unused.

35. A method according to claim 32, **characterised in that** each mobile station has a given temporary logic identifier in order to distinguish the mobile station from other mobile stations operating under the same base station subsystem, and in order to reserve radio resources for the use of a radio connection for parallel downlink realtime data transmission services, the base station subsystem sends the mobile station a paging message, where it indicates

- the temporary logic identifier of the mobile station
- the location of the regularly repeated slots allocated to the parallel radio connection and
- an additional identifier, which distinguishes the parallel radio connection from other ongoing radio connections convoying realtime data transmission services.

36. A method according to claim 31, where the radio system additionally offers the mobile station realtime and non-realtime data transmission services, **characterised in that** in order to form a radio connection for downlink non-realtime data transmission services, the base station subsystem indicates in the paging message (41, 42) the location of the first slots for non-realtime data transmission services in relation to the frame structure, and to announce a change in either the location or the amount of the slots allocated for non-realtime data transmission services during the connection, the base station subsystem notifies the new location or amount of the slots by sending a new paging message.

37. A base station subsystem for a radio telecommunication system having base station subsystems and mobile stations, the base station subsystem having means for arranging the communicated information into chronologically consecutive frames, **characterised in that** the base station subsystem additionally comprises means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: frequency, code;

and the size of said slot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection taking into account data transmission capacity changes during an ongoing radio connection.

38. A base station subsystem according to claim 37, **characterised in that** it further comprises means for maintaining a reservation table in order to indicate the size and state of occupancy of the slots in the frames and in order to maintain an optimal rate of usage.

39. A base station subsystem according to claim 38, **characterised in that** it further comprises means for communicating information concerning reservation tables with its neighbouring base station subsystems.

40. A base station subsystem according to claim 37, **characterized in that** in order to set up uplink connections it further comprises means for

- producing a general access slot location announcement and transmitting it to all mobile stations in a predetermined downlink slot in order to advice the mobile stations to send capacity requests in the announced access slot,
- receiving and interpreting capacity requests from the mobile stations,
- making slot allocation decisions that allocate slots to radio connections requested and identified in the capacity requests and
- producing access granting messages and transmitting them in a predetermined slot selectively to those mobile stations whose capacity requests were granted in the slot allocation decisions.

41. A base station subsystem according to claim 37, **characterized in that** in order to set up downlink connections it further comprises means for

- producing paging messages and transmitting them in a predetermined slot selectively to those mobile stations to which a downlink connection is to be established, said paging messages indicating at least one allocated downlink slot,
- receiving and interpreting paging acknowledgement messages from the mobile stations, and
- directing a downlink transmission into the allocated downlink slots indicated in the paging message.

42. A mobile station for a radio telecommunication system having base station subsystems and mobile stations, the mobile station having means for arranging the communicated information into chronologically consecutive frames, **characterised in that** the mobile station additionally comprises means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: frequency, code;

and the size of said slot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection taking into account data transmission capacity changes during an ongoing radio connection.

43. A mobile station according to claim 42, **characterized in that** in order to set up uplink connections it further comprises means for

- receiving and interpreting access slot location announcements transmitted from a base station subsystem,
- producing a capacity request and transmitting it in an access slot identified in an access slot location announcement,
- receiving and interpreting an access grant message from the base station subsystem identifying at least one granted slot and
- directing information transmissions into said at least granted slot.

44. A mobile station according to claim 42, **character-**

ized in that in order to se[illegible]ownlink connections it further comprises means for

- receiving and interpreting paging messages transmitted from a base station subsystem, said paging messages indicating at least one allocated downlink slot,
- producing a paging acknowledgement message and transmitting it in an acknowledgement slot, and
- receiving and interpreting downlink transmissions in said at least one allocated downlink slot.

45. A mobile station according to claim 44, **characterised in that** it further comprises means for identifying the acknowledgement slot on the basis of the information included in a paging message.

46. A radio telecommunication system having base station subsystems and mobile stations, the base station subsystems and mobile stations having means for arranging the communicated information into chronologically consecutive frames, **characterised in that** the base station subsystems and mobile stations additionally comprise means for directing the communicated information of each radio connection into at least one cyclically repeated two-dimensional slot in the frames, in which case

- the data transmission capacity of each slot is determined by the dimensions of the slot, and at least one frame contains slots of different data transmission capacities,
- each slot represents a given share of the physical resources contained in the frame,
- a multitude of slots in each frame are each dynamically assignable for the use of a given radio connection for the duration of the frame,
- the first dimension of the slots is time and the second dimension of the slots is one of the following: frequency, code;

and the size of said slot in relation to the size of a frame is dependent on the data transmission capacity required by the respective radio connection taking into account data transmission capacity changes during an ongoing radio connection.

Patentansprüche

1. Verfahren zum Steuern physikalischer Funkressourcen in einem Funksystem mit einem Basisstations-Untersystem und mehreren Mobilstationen in Funkverbindung mit diesem, **dadurch gekennzeichnet, dass**

- die physikali[illegible] Funkressourcen in chronologisch aufeinanderfolgende Rahmen (14) unterteilt werden, wobei die Rahmen zweidimensionale Schlitze (16, 17, 18) mit variablen Datenübertragungskapazitäten enthalten, in welchem Fall
  - -- die Datenübertragungskapazität jedes Schlitzes durch die Dimensionen des Schlitzes bestimmt wird und mindestens ein Rahmen Schlitze verschiedener Datenübertragungskapazitäten enthält;
  - -- jeder Schlitz einen vorgegebenen Anteil der im Rahmen enthaltenen physikalischen Ressourcen repräsentiert;
  - -- eine Anzahl von Schlitzen in mindestens einem Rahmen zur Verwendung bei einer vorgegebenen Funkverbindung für die Dauer des Rahmens dynamisch zuweisbar ist;
  - -- die erste Dimension der Schlitze die Zeit ist und die zweite Dimension der Schlitze eine der folgenden Größen ist: Frequenz, Code;
- und das Basisstations-Untersystem eine Entscheidung betreffend das Zuordnen der Schlitze für die Funkverbindungen auf Grundlage des Folgenden trifft:
  - -- der Datenübertragungserfordernisse der Funkverbindungen;
  - -- der Änderungen der Datenübertragungserfordernisse der Funkverbindungen, wie sie während derselben auftreten; und
  - -- der Belegungsgröße und des Belegungszustands der Schlitze.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die im Rahmen enthaltenen Schlitze, entsprechend dem Volumen der jeweiligen physikalischen Funkressourcen, zu mindestens zwei verschiedenen zugelassenen Größenkategorien gehören und dass zum Ändern der Schlitzstruktur eines Rahmens eine vorbestimmte ganzzahlige Anzahl der Schlitze der ersten Größenkategorie durch eine vorbestimmte ganzzahlige Anzahl der Schlitze der zweiten Größenkategorie ersetzt werden kann.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** die Anzahl der zulässigen Größenkategorien drei ist, in welchem Fall der Schlitz (16) der größten Größenkategorie zwei Schlitzen (17) der nächstgrößten Größenkategorie oder zehn Schlitzen (18) der kleinsten Größenkategorie entspricht.

4. Verfahren nach Anspruch 2, **dadurch gekenn-**

zeichnet, dass die Anza[illegible] zulässigen Größenkategorien vier ist, in welchem Fall der Schlitz der größten Größenkategorie zwei Schlitzen der nächstgrößten Größenkategorie, vier Schlitzen der drittgrößten Größenkategorie oder acht Schlitzen der kleinsten Größenkategorie entspricht.

5. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** jeder Rahmen, in der Richtung der ersten Dimension, in eine vorbestimmte Anzahl von Zeitschlitzen (15) unterteilt ist und jeder Zeitschlitz ferner in Schlitze unterteilt ist.

6. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** jeder Schlitz den gesamten Frequenzbereich des entsprechenden Zeitschlitzes belegt, jedoch die Länge jedes Schlitzes in der Zeitdimension von seiner Datenübertragungskapazität abhängt.

7. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** Zeit-Frequenzmultiplex angewandt wird, wobei jeder Zeitschlitz die gesamte chronologische Dauer des entsprechenden Zeitschlitzes belegt, jedoch die Breite jedes Schlitzes in der Frequenzdimension von seiner Datenübertragungskapazität abhängt.

8. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** Zeit-Codemultiplex angewandt wird, wobei jeder Schlitz die gesamte chronologische Dauer des entsprechendes Zeitschlitzes belegt, jedoch die Datenübertragungskapazität jedes Schlitzes vom entsprechenden Spreizcode abhängt.

9. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** eine vorbestimmte, nicht negative ganzzahlige Anzahl aufeinanderfolgender Rahmen einen Superrahmen (19) bildet, so dass in aufeinanderfolgenden Superrahmen derartige Rahmen, die an ähnlichen Positionen liegen, wenn vom Beginn des Superrahmens ausgegangen wird, einander in Bezug auf die Schlitzunterteilung entsprechen, wenn bei den Datenübertragungserfordernissen der Funkverbindungen zwischen den Superrahmen keine Änderungen auftraten.

10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** jeder Superrahmen sowohl Schlitze (I) beinhaltet, die zur Übertragung von Information vorgesehen sind, sowie Steuerschlitze (C) zum Realisieren logischer Steuerkanäle.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** ein Abwärtsstreckesignal einen allgemeinen Logiksteuerkanal (47) enthält, der zur Signalgabe, in Verbindung mit schlitzweiser Funkressourcensteuerun[illegible]handen ist.

12. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** jeder Steuerschlitz (C) entsprechend den durch ihn repräsentierten physikalischen Funkressourcen zu einer der zulässigen Größenkategorien gehört.

13. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** ein vorbestimmtes Frequenzband dazu verwendet wird, sowohl Abwärtsübertragungsstrecke- als auch Aufwärtsübertragungsstrecke-Schlitze entsprechend einem Zeitduplexschema zu transportieren.

14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** eine vorbestimmte, nicht negative ganze Anzahl aufeinanderfolgener Rahmen einen Superrahmen (19) bildet und jeder Superrahmen eine erste Anzahl von Abwärtsübertragungsstrecke-Rahmen und eine zweite Anzahl von Aufwärtsübertragungsstrecke-Rahmen enthält.

15. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** ein vorbestimmtes erstes Frequenzband dazu verwendet wird, nominelle Abwärtsstreckeschlitze zu transportieren und ein vorbestimmtes zweites Frequenzband dazu verwendet wird, nominelle Aufwärtsstreckeschlitze zu transportieren, wobei jedoch auf unsymmetrische Verkehrsbedingungen in der Richtung der Aufwärts- und der Abwärtsübertragungsstrecke-Schlitze kreuzweise so zugeordnet werden, dass nominelle Abwärtsübertragungsstrecke-Schlitze dazu verwendet werden, Aufwärtsübertragungsstrecke-Verkehr zu transportieren, oder nominelle Aufwärtsübertragungsstrecke-Schlitze dazu verwendet werden, Abwärtsübertragungsstrecke-Verkehr zu transportieren.

16. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem eine Reservierungstabelle aufrecht erhält, um die Belegungsgröße und den Belegungszustand der Schlitze in den Rahmen anzuzeigen und um eine optimale Nutzungsrate aufrecht zu erhalten.

17. Verfahren nach Anspruch 16, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem die Qualität mindestens eines zuordenbaren Schlitzes bewertet und eine Entscheidung betreffend die Zuordnung oder Nichtzuordnung des Schlitzes zu einer Verbindung auf Grundlage der durch die Erfindung benötigten Übertragungsqualität trifft.

18. Verfahren nach Anspruch 16, **dadurch gekennzeichnet, dass** es im Basisstations-Untersystem Schritte beinhaltet, bei denen, als Reaktion auf eine

Schlitzanforderung

- entweder eine Aufwärtsübertragungsstrecke- oder eine Abwärtsübertragungsstrecke-Reservierungstabelle ausgewählt wird;
- eine Reservierungstabelle ausgewählt wird;
- ein Satz von Kandidatenzeitschlitzen aus der gewählten Reservierungstabelle gebildet wird;
- ein Satz vorbestimmter Auswählkriterien ausgewählt wird, um den besten Kandidatenzeitschlitz aufzufinden;
- die vom ausgewählten besten Kandidatenzeitschlitz gebotene Übertragungsqualität geprüft wird und
- eine Entscheidung zum Zuordnen eines Schlitzes aus dem besten Kandidatenzeitschlitz getroffen wird.

19. Verfahren nach Anspruch 16, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem eine Entscheidung zum Zuordnen der Schlitze für die Funkübertragungen auch auf Grundlage der Information trifft, die in den Reservierungstabellen benachbarter Basisstations-Untersysteme enthalten ist.

20. Verfahren nach Anspruch 19, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem Schlitze auf Grundlage der zur Kommunikation durch verschiedene Mobilstationen verwendeten Übertragungsleistung so zuordnet, dass einer ersten Mobilstation, die für die Kommunikation mit einer ersten Basisstation eine niedrige Übertragungsleistung verwendet, ein Schlitz zugeordnet wird, der chronologisch mit einem Schlitz übereinstimmt, der einer zweiten Mobilstation zugeordnet wird, die für die Kommunikation mit einer zweiten Basisstation eine hohe Übertragungsleistung verwendet.

21. Verfahren nach Anspruch 19, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem Schlitze auf Grundlage des durch verschiedene Mobilstationen verwendeten Kommunikationstyps so zuordnet, dass leitungsvermittelte und paketvermittelte Verbindungen ihre eigenen Schlitze aufweisen, die in den Reservierungstabellen benachbarter Basisstationen an optimalen Stellen in Bezug auf die Gesamtwechselwirkung des Systems liegen.

22. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es zum Einstellen einer Aufwärtsübertragungsstrecke-Funkverbindung zwischen dem Basisstations-Untersystem und der Mobilstation die folgenden Schritte aufweist:

- Senden, von der Mobilstation, in einem Anfrageschlitz für zulässige Aufwärtsübertragungsstrecke-Kapazität, einer Kapazitätsanforderung (21, 35), in der die Mobilstation den für die Funkverbindung benötigten Umfang physikalischer Funkressourcen anzeigt; und
- Treffen einer Zuordnungsentscheidung im Basisstations-Untersystem als Antwort auf die Kapazitätsanforderung.

23. Verfahren nach Anspruch 22, **dadurch gekennzeichnet, dass** der Ort und die Menge der Anfrageschlitze für die zulässige Aufwärtsübertragungsstrecke-Kapazität in Bezug auf die Rahmenstruktur nicht konstant ist und das Basisstations-Untersystem in einem vorbestimmten Abwärtsübertragungsstrecke-Schlitz eine Ankündigung überträgt, die den Ort und die Menge der Anforderungsschlitze für die zulässige Aufwärtsübertragungsstrecke-Kapazität anzeigt.

24. Verfahren nach Anspruch 22, bei dem das Funksystem der Mobilstation zusätzlich Datenübertragungsdienste in Echtzeit und Nicht-Echtzeit anbietet, **dadurch gekennzeichnet, dass** zum Reservieren von Funkressourcen zur Verwendung bei einer Funkverbindung für Aufwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit die Mobilstation in ihrer Kapazitätsanforderung (21) die benötigte Datenübertragungskapazität anzeigt.

25. Verfahren nach Anspruch 24, **dadurch gekennzeichnet, dass** die Mobilstation in ihrer Kapazitätsanforderung zusätzlich einen vorbestimmten Satz von Parametern anzeigt, der die benötigten Qualitäten der Funkverbindung beschreibt.

26. Verfahren nach Anspruch 24, **dadurch gekennzeichnet, dass** dann, wenn der Bedarf an Datenübertragungskapazität während einer andauernden Funkverbindung für Aufwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit zunimmt, die Mobilstation eine Kapazitätsanforderung (24) an das Basisstations-Untersystem sendet, in der sie die benötigte zusätzliche Datenübertragungskapazität anzeigt.

27. Verfahren nach Anspruch 24, **dadurch gekennzeichnet, dass** dann, wenn der Bedarf an Datenübertragungskapazität während einer andauernden Funkverbindung für Aufwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit mit mehreren zugeordneten Schlitzen abnimmt, die Mobilstation mindestens einen der zugeordneten Schlitze unbenutzt belässt.

28. Verfahren nach Anspruch 24, **dadurch gekennzeichnet, dass** jede Mobilstation über eine bestimmte zeitliche Logikkennung verfügt, um die Mo-

bilstation von anderen Mobilstationen zu unterscheiden, die unter demselben Basisstations-Untersystem arbeiten, und wobei die Mobilstation, um Funkressourcen für die Verwendung einer Funkverbindung für parallele Aufwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit zu reservieren, eine Kapazitätsanforderung an das Basisstations-Untersystem sendet, in der sie

- ihre zeitweilige Logikkennung anzeigt;
- die benötigte Parallel-Datenübertragungskapazität anzeigt; und
- eine zusätzliche Kennung anzeigt, die die parallele Funkverbindung von anderen andauernden Funkverbindungen unterscheidet, die Datenübertragungsdienste in Echtzeit transportieren.

29. Verfahren nach Anspruch 22, bei dem das Funksystem der Mobilstation zusätzlich Datenübertragungsdienste in Echtzeit und in Nicht-Echtzeit anbietet, **dadurch gekennzeichnet, dass** die Mobilstation, um Funkressourcen zur Verwendung bei einer Funkverbindung für Aufwärtsübertragungsstrecke-Datenübertragungsdienste in Nicht-Echtzeit zu reservieren, in ihrer Kapazitätsanforderung (21) die zu übertragende Datenmenge anzeigt.

30. Verfahren nach Anspruch 22, **dadurch gekennzeichnet, dass** das Basisstations-Untersystem in seiner Zuordnungsentscheidung die Freiheit hat, die benötigte Funkverbindung in jeden beliebig verfügbaren Schlitz zu lenken, wobei das Basisstations-Untersystem nach der Zuordnungsentscheidung in einem vorbestimmten Abwärtsübertragungsstrecke-Zugriffsgewährungsschlitz eine Anzeige über den gewährten Schlitz oder die gewährten Schlitze an die Mobilstation sendet.

31. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es zum Aufbauen einer Abwärtsübertragungsstrecke-Funkverbindung zwischen dem Basisstations-Untersystem und der Mobilstation die folgenden Schritte aufweist:

- Treffen einer Zuordnungsentscheidung im Basisstations-Untersystem als Antwort auf das erkannte Erfordernis einer neuen Abwärtsübertragungsstrecke-Funkverbindung, die die Menge physikalischer Funkressourcen anzeigt, wie sie durch die Funkverbindung benötigt werden;
- Senden einer Funkrufmeldung (27, 28, 41, 42) an die Mobilstation, die den Ort des mindestens einen Abwärtsübertragungsstrecke-Schlitzes anzeigt, der der Funkverbindung bei der Zuordnungsentscheidung zugeordnet wurde;
- Senden, als Reaktion auf eine erkannte Funkrufmeldung, einer Funkruf-Bestätigungsmeldung von der Mobilstation; und
- Beginnen, als Reaktion auf eine erkannte Funkruf-Bestätigungsmeldung, einer Abwärtsübertragungsstrecke-Übertragung vom Basisstations-Untersystem.

32. Verfahren nach Anspruch 31, bei dem das Funksystem der Mobilstation zusätzlich Datenübertragungsdienste in Echtzeit und in Nicht-Echtzeit anbietet, **dadurch gekennzeichnet, dass** zum Erstellen einer Funkverbindung für Abwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit das Basisstations-Untersystem in der Funkrufmeldung (27, 28) für die regelmäßig wiederholten Schlitze, wie sie der Funkverbindung zugeordnet sind, deren Ort in Beziehung zur Rahmenstruktur anzeigt.

33. Verfahren nach Anspruch 32, **dadurch gekennzeichnet, dass** dann, wenn der Bedarf an Datenübertragungskapazität während einer andauernden Funkverbindung für Abwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit zunimmt, das Basisstations-Untersystem eine zusätzliche Schlitzzuordnungsentscheidung trifft und an die Mobilstation eine Funkrufmeldung (27, 28, 41, 42) meldet, die den Ort des mindestens einen zusätzlichen Abwärtsübertragungsstrecke-Schlitzes, der der Funkverbindung zugeordnet wurde, mitteilt.

34. Verfahren nach Anspruch 32, **dadurch gekennzeichnet, dass** dann, wenn der Bedarf an Datenübertragungskapazität während einer andauernden Funkverbindung für Abwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit mehreren zugeordneten Schlitzen abnimmt, die Basisstation eine Schlitzzuordnungs-Aufhebeentscheidung betreffend mindestens einen der zugeordneten Schlitze trifft und die entsprechenden Schlitze unbenutzt belässt.

35. Verfahren nach Anspruch 32, **dadurch gekennzeichnet, dass** jede Mobilstation über eine vorgegebene zeitweilige Logikkennung verfügt, um die Mobilstation von anderen Mobilstationen zu unterscheiden, die unter demselben Basisstations-Untersystem arbeiten, und dass das Basisstations-Untersystem, um Funkressourcen für die Verwendung einer Funkverbindung für parallele Abwärtsübertragungsstrecke-Datenübertragungsdienste in Echtzeit zu reservieren, eine Funkrufmeldung an die Mobilstation sendet, in der sie Folgendes anzeigt:

- die vorübergehende Logikkennung der Mobilstation;
- den Ort der regelmäßig beabstandeten Schlitze, die der parallelen Funkverbindung zugeord-

net sind; und

- eine zusätzliche Kennung, die die parallele Funkverbindung von anderen andauernden Funkverbindungen unterscheidet, die Datenübertragungsdienste in Echtzeit transportieren.

36. Verfahren nach Anspruch 31, bei dem das Funksystem der Mobilstation zusätzlich Datenübertragungsdienste in Echtzeit und in Nicht-Echtzeit anbietet, **dadurch gekennzeichnet, dass** zum Erstellen einer Funkverbindung für Abwärtsübertragungsstrecke-Datenübertragungsdienste in Nicht-Echtzeit das Basisstations-Untersystem in der Funkrufmeldung (41, 42) den Ort der ersten Schlitze für Datenübertragungsdienste in Nicht-Echtzeit in Beziehung zur Rahmenstruktur anzeigt, und dass das Basisstations-Untersystem, um eine Änderung entweder hinsichtlich des Orts oder der Menge der für Datenübertragungsdienste in Nicht-Echtzeit während der Verbindung zugeordneten Schlitze anzukündigen, den neuen Ort oder die neue Menge der Schlitze durch Senden einer neuen Funkrufmeldung mitteilt.

37. Basisstations-Untersystem für ein Funk-Telekommunikationssystem mit Basisstations-Untersystemen und Mobilstationen, wobei das Basisstations-Untersystem über eine Einrichtung zum Anordnen der mitgeteilten Information in chronologisch aufeinanderfolgenden Rahmen verfügt, **dadurch gekennzeichnet, dass**

- das Basisstations-Untersystem zusätzlich eine Einrichtung zum Lenken der mitgeteilten Information jeder Funkverbindung in mindestens einen zyklisch wiederholten zweidimensionalen Schlitz in den Rahmen aufweist, in welchem Fall
  - -- die Datenübertragungskapazität jedes Schlitzes durch die Dimensionen des Schlitzes bestimmt wird und mindestens ein Rahmen Schlitze verschiedener Datenübertragungskapazitäten enthält;
  - -- jeder Schlitz einen vorgegebenen Anteil der im Rahmen enthaltenen physikalischen Ressourcen repräsentiert;
  - -- eine Anzahl von Schlitzen in jedem Rahmen für die Verwendung in einer vorgegebenen Funkverbindung für die Dauer des Rahmens dynamisch zuordenbar ist;
  - -- die erste Dimension der Schlitze die Zeit ist und die zweite Dimension der Schlitze eine der folgenden Größen ist: Frequenz, Code;
- und die Größe des Schlitzes in Beziehung zur Größe eines Rahmens von der Datenübertragungskapazität abhängt, wie sie durch die jeweilige Funkverbindung benötigt wird, wenn Änderungen der Datenübertragungskapazität während einer andauernden Funkverbindung berücksichtigt werden.

38. Basisstations-Untersystem nach Anspruch 37, **dadurch gekennzeichnet, dass** es ferner eine Einrichtung zum Aufrechterhalten einer Reservierungstabelle aufweist, um die Belegungsgröße und den Belegungszustand der Schlitze im Rahmen anzuzeigen und um eine optimale Nutzungsrate aufrecht zu erhalten.

39. Basisstations-Untersystem nach Anspruch 38, **dadurch gekennzeichnet, dass** es ferner eine Einrichtung zum Mitteilen von Information betreffend Reservierungstabellen in den benachbarten Basisstations-Untersystemen aufweist.

40. Basisstations-Untersystem nach Anspruch 37, **dadurch gekennzeichnet, dass** es zum Errichten von Aufwärtsübertragungsstrecke-Verbindungen ferner Einrichtungen für Folgendes aufweist:

- Erzeugen einer allgemeinen Zugriffsschlitzort-Ankündigung und Senden derselben an alle Mobilstationen in einem vorbestimmten Abwärtsübertragungsstrecke-Schlitz, um die Mobilstationen anzuweisen, Kapazitätsanforderungen an den angekündigten Zugriffsschlitz zu senden;
- Empfangen und Interpretieren von Kapazitätsanforderungen von den Mobilstationen;
- Treffen von Schlitzzuordnungsentscheidungen, die in den Kapazitätsanforderungen angeforderten und **gekennzeichneten** Funkverbindungen Schlitze zuordnen; und
- Erzeugen von Zugriffsgewährungsmeldungen und Senden derselben auf selektive Weise in einem vorbestimmten Schlitz an diejenigen Mobilstationen, deren Kapazitätsanforderungen in den Schlitzzuordnungsentscheidungen gewährt wurden.

41. Basisstations-Untersystem nach Anspruch 37, **dadurch gekennzeichnet, dass** sie zum Errichten von Abwärtsübertragungsstrecke-Verbindungen ferner Einrichtungen für Folgendes aufweist:

- Erzeugen von Funkrufmeldungen und selektives Senden derselben in einem vorbestimmten Schlitz an diejenigen Mobilstationen, mit denen eine Abwärtsübertragungsstrecke-Verbindung zu errichten ist, wobei die Funkrufmeldungen mindestens einen zugeordneten Abwärtsübertragungsstrecke-Schlitz anzeigen;

- Empfangen und Interpretieren von Funkruf-Bestätigungsmeldungen von den Mobilstationen; und
- Lenken einer Abwärtsübertragungsstrecke-Übertragung in die in der Funkrufmeldung angezeigten zugeordneten Abwärtsübertragungsstrecke-Schlitze.

42. Mobilstation für ein Funk-Telekommunikationssystem mit Basisstations-Untersystemen und Mobilstationen, wobei die Mobilstation eine Einrichtung zum Anordnen der mitgeteilten Information in chronologisch aufeinanderfolgenden Rahmen aufweist, **dadurch gekennzeichnet, dass**

- die Mobilstation zusätzlich eine Einrichtung zum Lenken der mitgeteilten Information jeder Funkverbindung in mindestens einen zyklisch wiederholten zweidimensionalen Schlitz in den Rahmen aufweist, in welchem Fall
  - -- die Datenübertragungskapazität jedes Schlitzes durch die Dimensionen des Schlitzes bestimmt wird und mindestens ein Rahmen Schlitze verschiedener Datenübertragungskapazitäten enthält;
  - -- jeder Schlitz einen vorgegebenen Anteil der im Rahmen enthaltenen physikalischen Ressourcen repräsentiert;
  - -- eine Anzahl von Schlitzen in jedem Rahmen für die Verwendung in einer vorgegebenen Funkverbindung für die Dauer des Rahmens dynamisch zuordenbar ist;
  - -- die erste Dimension der Schlitze die Zeit ist und die zweite Dimension der Schlitze eine der folgenden Größen ist: Frequenz, Code;
- und die Größe des Schlitzes in Beziehung zur Größe eines Rahmens von der Datenübertragungskapazität abhängt, wie sie durch die jeweilige Funkverbindung benötigt wird, wenn Änderungen der Datenübertragungskapazität während einer andauernden Funkverbindung berücksichtigt werden.

43. Mobilstation nach Anspruch 42, **dadurch gekennzeichnet, dass** sie zum Errichten von Aufwärtsübertragungsstrecke-Verbindungen ferner eine Einrichtung für Folgendes aufweist:

- Empfangen und Interpretieren von von einem Basisstations-Untersystem übertragenen Zugriffsschlitzort-Ankündigungen;
- Erzeugen einer Kapazitätsanforderung und Senden derselben in einem Zugriffsschlitz, wie er in einer Zugriffsschlitzort-Ankündigung **gekennzeichnet** wurde;
- Empfangen und Interpretieren einer Zugriffsgewährungsmeldung vom Basisstations-Untersystem, die mindestens einen gewährten Schlitz **kennzeichnet**; und
- Lenken von Informationsübertragungsvorgängen in den mindestens einen gewährten Schlitz.

44. Mobilstation nach Anspruch 42, **dadurch gekennzeichnet, dass** sie zum Errichten von Abwärtsübertragungsstrecke-Verbindungen ferner Einrichtungen für Folgendes aufweist:

- Empfangen und Interpretieren von von einem Basisstations-Untersystem übertragenen Funkrufmeldungen, die mindestens einen zugeordneten Abwärtsübertragungsstrecke-Schlitz anzeigen;
- Erzeugen einer Funkruf-Bestätigungsmeldung und Senden derselben in einem Bestätigungsschlitz; und
- Empfangen und Interpretieren von Abwärtsübertragungsstrecke-Übertragungsvorgängen in den mindestens einen zugeordneten Abwärtsübertragungsstrecke-Schlitz.

45. Mobilstation nach Anspruch 44, **dadurch gekennzeichnet, dass** sie ferner eine Einrichtung zum Erkennen des Bestätigungsschlitzes auf Grundlage der in einer Funkrufmeldung enthaltenen Information aufweist.

46. Funk-Telekommunikationssystem mit Basisstations-Untersystemen und Mobilstationen, wobei das Basisstations-Untersystem über eine Einrichtung zum Anordnen der mitgeteilten Information in chronologisch aufeinanderfolgenden Rahmen verfügt, **dadurch gekennzeichnet, dass**

- die Basisstations-Untersysteme und MObilstationen zusätzlich eine Einrichtung zum Lenken der mitgeteilten Information jeder Funkverbindung in mindestens einen zyklisch wiederholten zweidimensionalen Schlitz in den Rahmen aufweisen, in welchem Fall
  - -- die Datenübertragungskapazität jedes Schlitzes durch die Dimensionen des Schlitzes bestimmt wird und mindestens ein Rahmen Schlitze verschiedener Datenübertragungskapazitäten enthält;
  - -- jeder Schlitz einen vorgegebenen Anteil der im Rahmen enthaltenen physikalischen Ressourcen repräsentiert;
  - -- eine Anzahl von Schlitzen in jedem Rahmen für die Verwendung in einer vorgegebenen Funkverbindung für die Dauer des Rahmens dynamisch zuordenbar ist;

-- die erste Dimension der Schlitze die Zeit ist und die zweite Dimension der Schlitze eine der folgenden Größen ist: Frequenz, Code;

- und die Größe des Schlitzes in Beziehung zur Größe eines Rahmens von der Datenübertragungskapazität abhängt, wie sie durch die jeweilige Funkverbindung benötigt wird, wenn Änderungen der Datenübertragungskapazität während einer andauernden Funkverbindung berücksichtigt werden.

Revendications

1. Procédé destiné à commander des ressources radiotéléphoniques physiques dans un système radiotéléphonique comprenant un sous-système de station de base et plusieurs stations mobiles en connexion radiotéléphonique avec celui-ci, **caractérisé en ce que** les ressources radiotéléphoniques physiques sont divisées en des trames consécutives chronologiquement (14), lesdites trames contenant des tranches à deux dimensions (16, 17, 18) possédant des capacités de transmission de données variables, auquel cas

- la capacité de transmission de données de chaque tranche est définie par les dimensions de la tranche, et au moins une trame contient des tranches de différentes capacités de transmission de données,
- chaque tranche représente une part donnée des ressources physiques contenues dans la trame,
- une multitude de tranches dans au moins une trame sont affectables dynamiquement pour l'utilisation d'une connexion radiotéléphonique donnée pour la durée de la trame,
- la première dimension des tranches est le temps et la seconde dimension des tranches est l'un parmi les suivants : la fréquence, le code,
- et le sous-système de station de base prend une décision d'allouer les tranches pour les connexions radiotéléphoniques sur la base
- des besoins de transmission de données des connexions radiotéléphoniques,
- des modifications des besoins de transmission de données des connexions radiotéléphoniques se produisant au cours des connexions radiotéléphoniques, et
- de la taille et de l'état d'occupation des tranches.

2. Procédé selon la revendication 1, **caractérisé en ce que** les tranches contenues dans la trame appartiennent, en fonction du volume des ressources radiotéléphoniques physiques respectives, à au moins deux catégories de taille allouées différentes, et **en ce que** de façon à changer la structure de tranche d'une trame, un nombre entier prédéterminé des tranches de la première catégorie de taille peut être remplacé par un nombre entier prédéterminé de tranches de la seconde catégorie de taille.

3. Procédé selon la revendication 2, **caractérisé en ce que** la quantité de catégories de taille allouées est de trois, auquel cas la tranche (16) de la catégorie de taille la plus grande est égale à deux tranches (17) de la catégorie de taille suivante la plus grande, ou de dix tranches (18) de la catégorie de taille la plus petite.

4. Procédé selon la revendication 2, **caractérisé en ce que** la quantité de catégories de taille allouées est de quatre, auquel cas la tranche de la catégorie de taille la plus grande est égale à deux tranches de la catégorie de taille suivante la plus grande, quatre tranches de la troisième catégorie de taille la plus grande ou huit tranches de la catégorie de taille la plus petite.

5. Procédé selon la revendication 1, **caractérisé en ce que** chaque trame est divisée, dans le sens de la première dimension, en une quantité prédéterminée de tranches de temps (15), et chaque tranche de temps est ensuite divisée en tranches.

6. Procédé selon la revendication 5, **caractérisé en ce que** chaque tranche occupe la plage de fréquences complète de la tranche de temps correspondante, mais la longueur de chaque tranche en dimension de temps dépend de sa capacité de transmission de données.

7. Procédé selon la revendication 5, **caractérisé en ce qu'**une division temps-fréquence est appliquée, grâce à quoi chaque tranche occupe la durée complète chronologique de la tranche de temps correspondante, mais la largeur de chaque tranche en dimension de fréquence dépend de sa capacité de transmission de données.

8. Procédé selon la revendication 5, **caractérisé en ce qu'**une division temps-code est appliquée, grâce à quoi chaque tranche occupe la durée chronologique complète de la tranche de temps correspondante, mais la capacité de transmission de données de chaque tranche dépend du code d'étalement correspondant.

9. Procédé selon la revendication 1, **caractérisé en ce qu'**un nombre entier non négatif prédéterminé de trames consécutives forme une supertrame (19),

de sorte que dans des supertrames consécutives, de telles trames qui sont situées à des positions semblables lorsqu'elles démarrent à partir du début de la supertrame correspondent les unes aux autres par rapport à la division de tranche, si des changements ne se sont pas produits dans le besoin de transmission de données des connexions radiotéléphoniques entre les supertrames.

10. Procédé selon la revendication 9, **caractérisé en ce que** chaque supertrame contient à la fois des tranches (I) destinées à une transmission d'informations, et des tranches de commande (C) destinées à réaliser des canaux de commandes logiques.

11. Procédé selon la revendication 10, **caractérisé en ce qu'**un signal de liaison descendante comprend un canal général de commande logique (47) prévu pour la signalisation, connecté à une commande de ressource radiotéléphonique à la manière d'une tranche.

12. Procédé selon la revendication 10, **caractérisé en ce que** chaque tranche de commande (C) appartient, en fonction des ressources radiotéléphoniques physiques ainsi représentées, à l'une des catégories de taille allouées.

13. Procédé selon la revendication 1, **caractérisé en ce qu'**une bande de fréquences prédéterminée est utilisée pour transporter à la fois les tranches de liaison descendante et les tranches de liaison montante selon un principe de duplexage à répartition dans le temps.

14. Procédé selon la revendication 13, **caractérisé en ce qu'**un nombre entier non négatif prédéterminé de trames consécutives forme une supertrame (19), et chaque supertrame contient un premier nombre de trames de liaison descendante et un second nombre de trames de liaison montante.

15. Procédé selon la revendication 13, **caractérisé en ce qu'**une première bande de fréquences prédéterminée est utilisée pour transporter nominalement des tranches de liaison descendante, et une seconde bande de fréquences prédéterminée est utilisée pour transporter nominalement des tranches de liaison montante, mais en réponse à des conditions de trafic non symétriques dans le sens de la liaison montante et de la liaison descendante, des tranches sont allouées de manière croisée de sorte que nominalement des tranches de liaison descendante sont utilisées pour transporter un trafic de liaison montante, ou nominalement, des tranches de liaison montante sont utilisées pour transporter un trafic de liaison descendante.

16. Procédé selon la revendication 1, **caractérisé en ce que** le sous-système de station de base entretient une table de réservation de façon à indiquer la taille et l'état d'occupation des tranches dans les trames, et de façon à entretenir un débit optimum d'utilisation.

17. Procédé selon la revendication 16, **caractérisé en ce que** le sous-système de station de base évalue la qualité d'au moins une tranche affectable, et prend une décision d'allocation ou de non allocation de ladite tranche à une connexion sur la base de la quantité de transmission demandée par ladite connexion.

18. Procédé selon la revendication 16, **caractérisé en ce qu'**il comprend dans le sous-système de station de base les étapes dans lesquelles, en réponse à une demande de tranche,

- une table de réservation soit de liaison montante, soit de liaison descendante est choisie,
- une table de réservation est choisie,
- un ensemble de tranches de temps candidates à partir de la table de réservation choisie est formé,
- un ensemble de critères de sélection prédéterminés est appliqué pour trouver la meilleure tranche de temps candidate,
- la qualité de transmission offerte par la meilleure tranche de temps candidate est contrôlée et,
- une décision d'allouer une tranche à partir de la meilleure tranche de temps candidate est prise.

19. Procédé selon la revendication 16, **caractérisé en ce que** le sous-système de station de base prend une décision d'allouer les tranches pour les connexions radiotéléphoniques également sur la base des informations contenues dans les tables de réservation des sous-systèmes de station de base voisins.

20. Procédé selon la revendication 19, **caractérisé en ce que** le sous-système de station de base alloue des tranches sur la base de la puissance d'émission utilisée pour une communication par différentes stations mobiles, de sorte qu'une première station mobile qui utilise une faible puissance d'émission pour communiquer avec une première station de base se verra allouer une tranche qui coïncide chronologiquement avec une tranche allouée à une seconde station mobile qui utilise une forte puissance d'émission pour communiquer avec une seconde station de base.

21. Procédé selon la revendication 19, **caractérisé en ce que** le sous-système de station de base alloue

des tranches sur la base [illegible]e de communication utilisé par les différentes stations mobiles, de sorte que les liaisons commutées et les liaisons à commutation de paquets possèdent leurs propres tranches situées dans les tables de réservation de stations de base adjacentes à des emplacements optimaux par rapport à l'interférence totale du système.

22. Procédé selon la revendication 1, **caractérisé en ce que** pour initialiser une connexion radiotéléphonique de liaison montante entre le sous-système de station de base et la station mobile, le procédé comprend les étapes consistant à

- transmettre à partir de la station mobile, dans une tranche de demande de capacité de liaison montante allouée, une demande de capacité (21, 35) où la station mobile indique la quantité de ressources radiotéléphoniques physiques demandées par la connexion radiotéléphonique, et
- prendre une décision d'allocation dans le sous-système de station de base comme réponse à ladite demande de capacité.

23. Procédé selon la revendication 22, **caractérisé en ce que** l'emplacement et la quantité des tranches de demandes de capacité de liaison montante allouées par rapport à la structure de trame ne sont pas constants, et le sous-système de station de base transmet, dans une tranche de liaison descendante prédéterminée, une annonce indiquant l'emplacement et la quantité des tranches de demandes de capacité de liaison montante attribuées.

24. Procédé selon la revendication 22, où le système radiotéléphonique offre en plus à la station mobile des services de transmission de données en temps réel et en temps différé, **caractérisé en ce que** de façon à réserver des ressources radiotéléphoniques pour l'utilisation d'une connexion radiotéléphonique pour des services de transmission de données en temps réel de liaison montante, la station mobile indique dans sa demande de capacité (21) la capacité de transmission de données requise.

25. Procédé selon la revendication 24, **caractérisé en ce que** la station mobile indique en plus dans sa demande de capacité un ensemble prédéterminé de paramètres décrivant les qualités requises de la connexion radiotéléphonique.

26. Procédé selon la revendication 24, **caractérisé en ce que** lorsque la demande de capacité de transmission de données augmente durant une connexion radio en cours pour des services de transmission de donné[illegible] temps réel de liaison montante, la station mobile envoie au sous-système de station de base une demande de capacité (24) où elle indique la capacité de transmission de données supplémentaire requise.

27. Procédé selon la revendication 24, **caractérisé en ce que**, lorsque la demande de capacité de transmission de données diminue durant une connexion radiotéléphonique en cours pour des services de transmission de données en temps réel de liaison montante ayant plusieurs tranches allouées, la station mobile laisse au moins l'une des tranches allouées non utilisée.

28. Procédé selon la revendication 24, **caractérisé en ce que** chaque station mobile comporte un certain identificateur logique temporaire de façon à distinguer la station mobile des autres stations mobiles fonctionnant dans le même sous-système de station de base, et de façon à réserver des ressources radiotéléphoniques pour l'utilisation d'une connexion radiotéléphonique pour des services de transmission de données en temps réel de liaison montante, la station mobile envoie au sous-système de station de base une demande de capacité où elle indique

- son identificateur logique temporaire
- la capacité de transmission de données en parallèle requise, et
- un identificateur supplémentaire, qui distingue la connexion radiotéléphonique en parallèle d'autres connexions radiotéléphoniques en cours transportant des services de transmission de données en temps réel.

29. Procédé selon la revendication 22, où le système radiotéléphonique offre en outre à la station mobile des services de transmission de données en temps réel et en temps différé, **caractérisé en ce que** de façon à réserver des ressources radiotéléphoniques pour l'utilisation d'une connexion radiotéléphonique pour des services de transmission de données en temps différé de liaison montante, la station mobile indique dans sa demande de capacité (21) la quantité de données à transmettre.

30. Procédé selon la revendication 22, **caractérisé en ce que** dans sa décision d'allocation, le sous-système de station de base a la liberté de diriger la connexion radiotéléphonique requise dans toute tranche disponible quelconque, et après la décision d'allocation le sous-système de station de base transmet à la station mobile dans une tranche prédéterminée de liaison descendante d'accord d'accès une indication de la tranche ou des tranches accordées.

31. Procédé selon la revendication 1, **caractérisé en ce que** pour initialiser une connexion radiotéléphonique de liaison descendante entre le sous-système de station de base et la station mobile, le procédé comprend les étapes consistant à

- prendre une décision d'allocation dans le sous-système de station de base comme réponse du besoin détecté d'une nouvelle connexion radiotéléphonique de liaison descendante indiquant la quantité de ressources radiotéléphoniques physiques requises par la connexion radiotéléphonique,
- transmettre à partir du sous-système de station de base à la station mobile un message de recherche de personne (27, 28, 41, 42) qui annonce l'emplacement de la tranche ou des tranches de liaison descendante allouées à la connexion radiotéléphonique dans ladite décision d'allocation,
- comme réponse à un message de recherche de personne détecté, transmettre à partir de la station mobile un message d'accusé de réception de recherche de personne, et
- comme réponse du message d'accusé de réception de recherche de personne détecté commencer la transmission de liaison descendante à partir du sous-système de station de base.

32. Procédé selon la revendication 31, où le système radiotéléphonique offre en outre à la station mobile des services de transmission de données en temps réel et en temps différé, **caractérisé en ce que** de façon à former une connexion radiotéléphonique pour des services de transmission de données en temps réel de liaison descendante, le sous-système de station de base indique dans le message de recherche de personne (27, 28), pour les tranches répétées régulièrement allouées à la connexion radiotéléphonique, leur emplacement par rapport à la structure de trame.

33. Procédé selon la revendication 32, **caractérisé en ce que** lorsque la demande de capacité de transmission de données augmente durant une connexion radiotéléphonique en cours pour des services de transmission de données en temps réel de liaison descendante, le sous-système de station de base prend une décision d'allocation de tranche supplémentaire, et envoie à la station mobile un message de recherche de personne (27, 28, 41, 42) qui annonce l'emplacement de la tranche ou des tranches des liaisons descendantes supplémentaires allouées à la connexion radiotéléphonique.

34. Procédé selon la revendication 32, **caractérisé en ce que** lorsque la demande de capacité de transmission de données diminue durant une connexion radiotéléphonique en cours pour des services de transmission de données en temps réel de liaison descendante comportant plusieurs tranches allouées, la station de base prend une décision de désallocation de tranche concernant au moins l'une des tranches allouées, et laisse les tranches correspondantes non utilisées.

35. Procédé selon la revendication 32, **caractérisé en ce que** chaque station mobile comporte un identificateur logique temporaire donné de façon à distinguer la station mobile d'autres stations mobiles fonctionnant dans le même sous-système de station de base, et de façon à réserver des ressources radiotéléphoniques pour l'utilisation d'une connexion radiotéléphonique pour des services de transmission de données en temps réel de liaison descendante en parallèle, le sous-système de station de base envoie à la station mobile un message de recherche de personne, où il indique,

- l'identificateur logique temporaire de la station mobile
- l'emplacement des tranches répétées régulièrement allouées à la connexion radiotéléphonique en parallèle et
- un identificateur supplémentaire, qui distingue la connexion radiotéléphonique en parallèle d'autres connexions radiotéléphoniques en cours transportant des services de transmission de données en temps réel.

36. Procédé selon la revendication 31, où le système radiotéléphonique offre en plus à la station mobile des services de transmission de données en temps réel et en temps différé, **caractérisé en ce que** de façon à former une connexion radiotéléphonique pour des services de transmission de données en temps différé de liaison descendante, le sous-système de station de base indique dans le message de recherche de personne (41, 42) l'emplacement des premières tranches de services de transmission de données en temps différé par rapport à la structure de trame, et de façon à annoncer une modification soit dans l'emplacement, soit dans la quantité des tranches allouées pour des services de transmission de données en temps différé durant la connexion, le sous-système de station de base précise le nouvel emplacement ou la quantité des tranches en envoyant un nouveau message de recherche de personne.

37. Sous-système de station de base pour un système de télécommunications radiotéléphoniques comportant des sous-systèmes de stations de base et des stations mobiles, le sous-système de station de base possédant un moyen destiné à agencer les

informations communiquées en des trames consécutives chronologiquement, **caractérisé en ce que** le sous-système de station de base comprend en outre un moyen destiné à diriger les informations communiquées de chaque connexion radiotéléphonique dans au moins une tranche à deux dimensions répétée cycliquement dans les trames, auquel cas

- la capacité de transmission de données de chaque tranche est déterminée par la dimension de la tranche, et au moins une trame contient des tranches de capacités différentes de transmission de données,
- chaque tranche représente une part donnée des ressources physiques contenues dans la trame,
- une multitude de tranches dans chaque trame sont chacune dynamiquement affectables pour l'utilisation d'une connexion radiotéléphonique donnée pour la durée de la trame,
- la première dimension des tranches est le temps et la seconde dimension des tranches est l'un parmi les suivants : la fréquence, le code,

et la taille de ladite tranche par rapport à la taille d'une trame dépend de la capacité de transmission de données requise par la connexion radiotéléphonique respective prenant en compte les modifications de capacité de transmission de données durant une connexion radiotéléphonique en cours.

38. Sous-système de station de base selon la revendication 37, **caractérisé en ce qu'**il comprend en outre un moyen destiné à entretenir une table de réservation de façon à indiquer la taille et l'état d'occupation des tranches dans les trames, et de façon à entretenir un débit optimum d'utilisation.

39. Sous-système de station de base selon la revendication 38, **caractérisé en ce qu'**il comprend en outre un moyen destiné à communiquer des informations concernant les tables de réservation avec ses sous-systèmes de station de base voisins.

40. Sous-système de station de base selon la revendication 37, **caractérisé en ce que** de façon à initialiser des connexions de liaison montante il comprend en outre un moyen destiné à

- produire une annonce générale d'emplacement de tranche d'accès, et à la transmettre à toutes les stations mobiles dans une tranche prédéterminée de liaison descendante de façon à informer les stations mobiles d'envoyer des demandes de capacité dans la tranche d'accès annoncée,
- recevoir et interpréter des demandes de capacité émanant des stations mobiles,
- prendre des décisions d'allocation de tranche qui allouent des tranches à des connexions radiotéléphoniques demandées, et identifiées dans les demandes de capacité et
- produire des messages d'accord d'accès, et les transmettre dans une tranche prédéterminée sélectivement aux stations mobiles dont les demandes de capacité ont été accordées dans les décisions d'allocation de tranches.

41. Sous-système de station de base selon la revendication 37, **caractérisé en ce que** de façon à initialiser des connexions de liaison descendante, il comprend en outre un moyen destiné à

- produire des messages de recherche de personne, et les transmettre dans une tranche prédéterminée sélectivement aux stations mobiles avec lesquelles une connexion de liaison descendante doit être établie, lesdits messages de recherche de personne indiquant au moins une tranche de liaison descendante allouée,
- recevoir et interpréter des messages d'accusé de réception de recherche de personne depuis les stations mobiles, et
- diriger une transmission de liaison descendante dans les tranches de liaison descendante allouées indiquées dans le message de recherche de personne.

42. Station mobile pour un système de télécommunications radiotéléphoniques comportant des sous-systèmes de station de base et des stations mobiles, la station mobile possédant un moyen destiné à agencer les informations communiquées en des trames consécutives chronologiquement, **caractérisée en ce que** la station mobile comprend en outre un moyen destiné à diriger les informations communiquées de chaque connexion radiotéléphonique dans au moins une tranche à deux dimensions répétée cycliquement dans les trames, auquel cas

- la capacité de transmission de données de chaque tranche est définie par les dimensions de la tranche, et au moins une trame contient des tranches de différentes capacités de transmission de données,
- chaque tranche représente une part donnée des ressources physiques contenues dans la trame,
- une multitude de tranches dans chaque trame sont chacune affectables dynamiquement pour l'utilisation d'une connexion radiotéléphonique donnée pour la durée de la trame,
- la première dimension des tranches est le

temps, et la seconde dimension des tranches est l'un parmi les suivants : la fréquence, le code,

et la taille de ladite tranche par rapport à la taille d'une trame dépend de la capacité de transmission de données requise par la connexion radiotéléphonique respective prenant en compte des modifications de capacité de transmission de données durant une connexion radiotéléphonique en cours.

43. Station mobile selon la revendication 42, **caractérisée en ce que** de façon à initialiser des connexions de liaison montante elle comprend en outre un moyen destiné à

- recevoir et interpréter des annonces d'emplacement de tranche d'accès transmises depuis un sous-système de station de base,
- produire une demande de capacité et la transmettre dans une tranche d'accès identifiée dans une annonce d'emplacement de tranche d'accès,
- recevoir et interpréter un message d'accord d'accès depuis le sous-système de station de base identifiant au moins une tranche accordée et
- diriger les transmissions d'informations dans ladite au moins une tranche accordée.

44. Station mobile selon la revendication 42, **caractérisée en ce que** de façon à initialiser des connexions de liaisons descendantes, elle comprend en outre un moyen destiné à

- recevoir et interpréter des messages de recherche de personne transmis depuis un sous-système de station de base, lesdits messages de recherche de personne indiquant au moins une tranche de liaison descendante allouée,
- produire un message d'accusé de réception de recherche de personne et le transmettre dans une tranche d'accusé de réception, et
- recevoir et interpréter les transmissions de liaison descendante dans ladite au moins une tranche de liaison descendante allouée.

45. Station mobile selon la revendication 44, **caractérisée en ce qu'**elle comprend en outre un moyen destiné à identifier la tranche d'accusé de réception sur la base des informations comprises dans un message de recherche de personne.

46. Système de télécommunications radiotéléphoniques comportant des sous-systèmes de stations de base et des stations mobiles, les sous-systèmes de stations de base et les stations mobiles comportant un moyen destiné à agencer les informations communiquées en tranches chronologiquement consécutives, **caractérisé en ce que** les sous-systèmes de stations de base et les stations mobiles comprennent en outre un moyen destiné à diriger les informations communiquées de chaque connexion radiotéléphonique vers au moins une tranche à deux dimensions répétée cycliquement dans les trames, auquel cas

- la capacité de transmission de données de chaque tranche est définie par les dimensions de la tranche, et au moins une trame contient des tranches de capacités de transmission de données différentes,
- chaque tranche représente une part donnée des ressources physiques contenues dans la trame,
- une multitude de tranches dans chaque trame sont chacune affectables dynamiquement pour l'utilisation d'une connexion radiotéléphonique donnée pour la durée de la trame,
- la première dimension des tranches est le temps, et la seconde dimension des tranches est l'un parmi les suivants : la fréquence, le code,

et la taille de ladite tranche par rapport à la taille d'une trame dépend de la capacité de transmission de données requise par la connexion radiotéléphonique respective prenant en compte les modifications de capacité de transmission de données durant une connexion radiotéléphonique en cours.

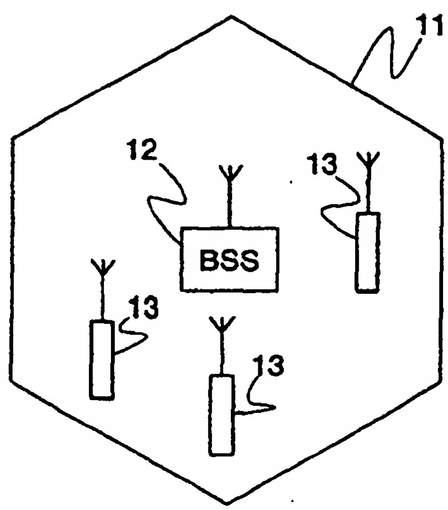


Fig.1
PRIOR ART

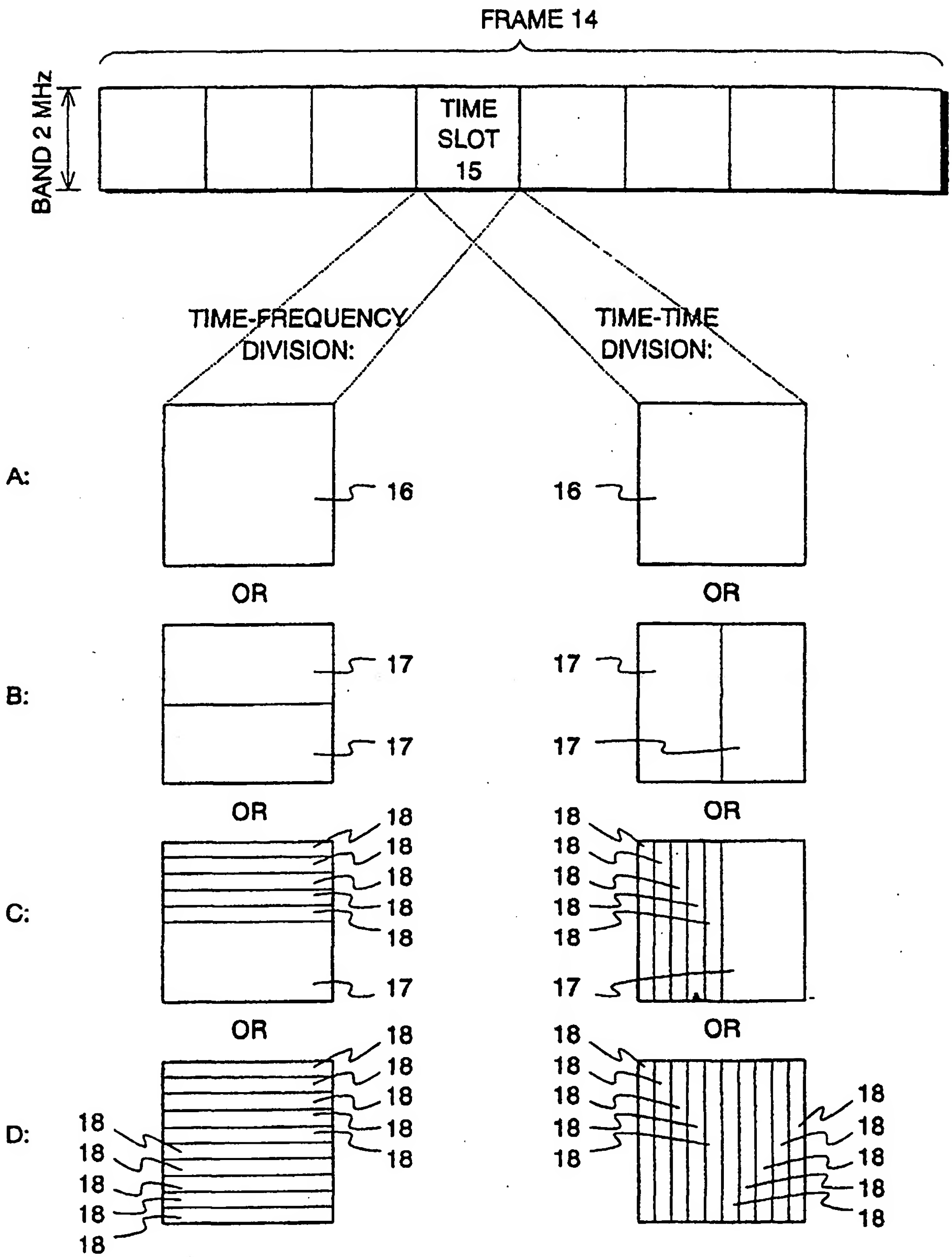

FRAME 14
BAND 2 MHz
TIME SLOT 15
TIME-FREQUENCY DIVISION:
TIME-TIME DIVISION:
A:
B:
C:
D:
OR
16
17
18

Fig. 2a

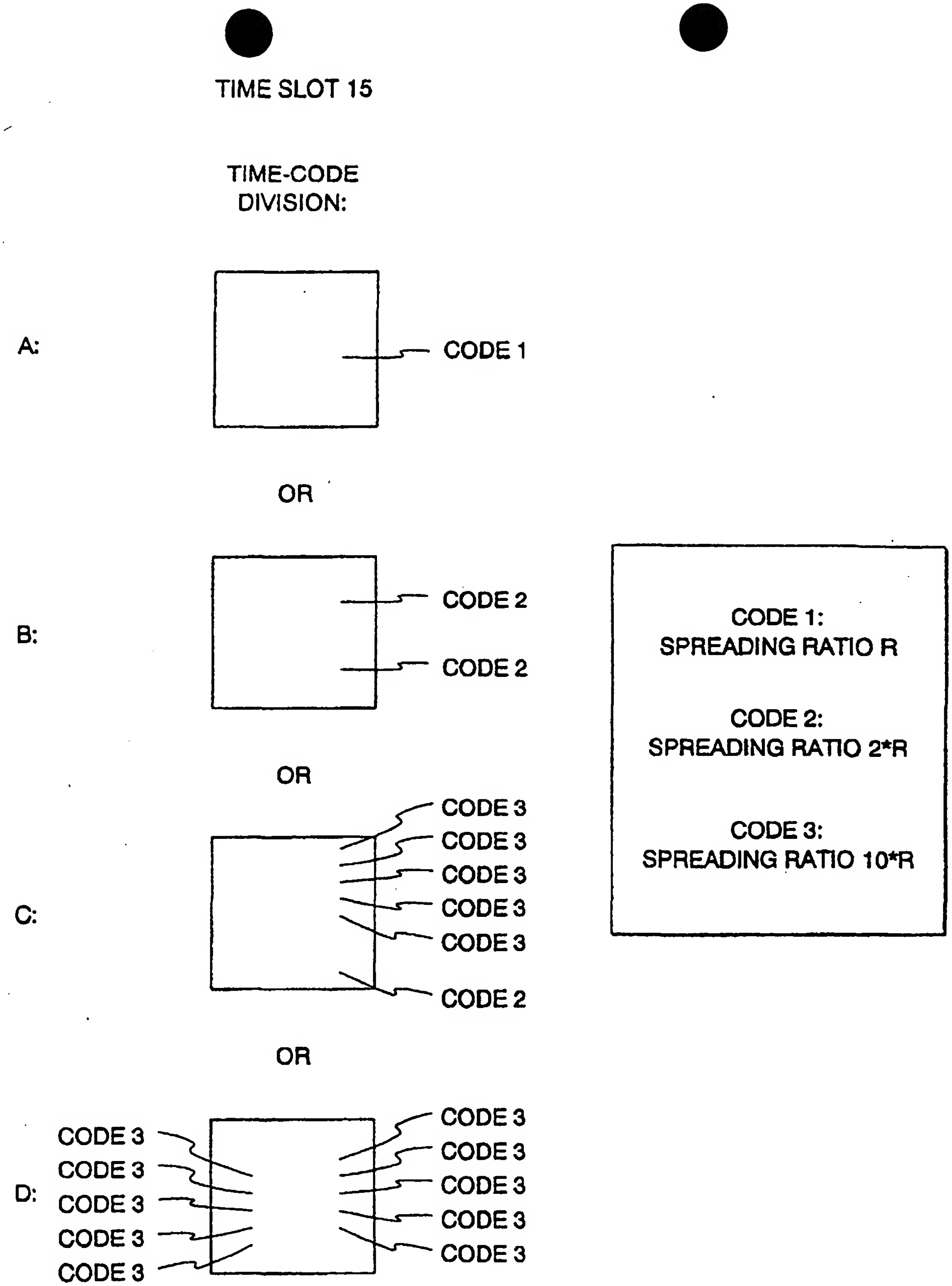

TIME SLOT 15
TIME-CODE DIVISION:
A:
CODE 1
OR
B:
CODE 2
CODE 2
OR
C:
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 2
OR
D:
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 3
CODE 1: SPREADING RATIO R
CODE 2: SPREADING RATIO 2*R
CODE 3: SPREADING RATIO 10*R

Fig. 2b

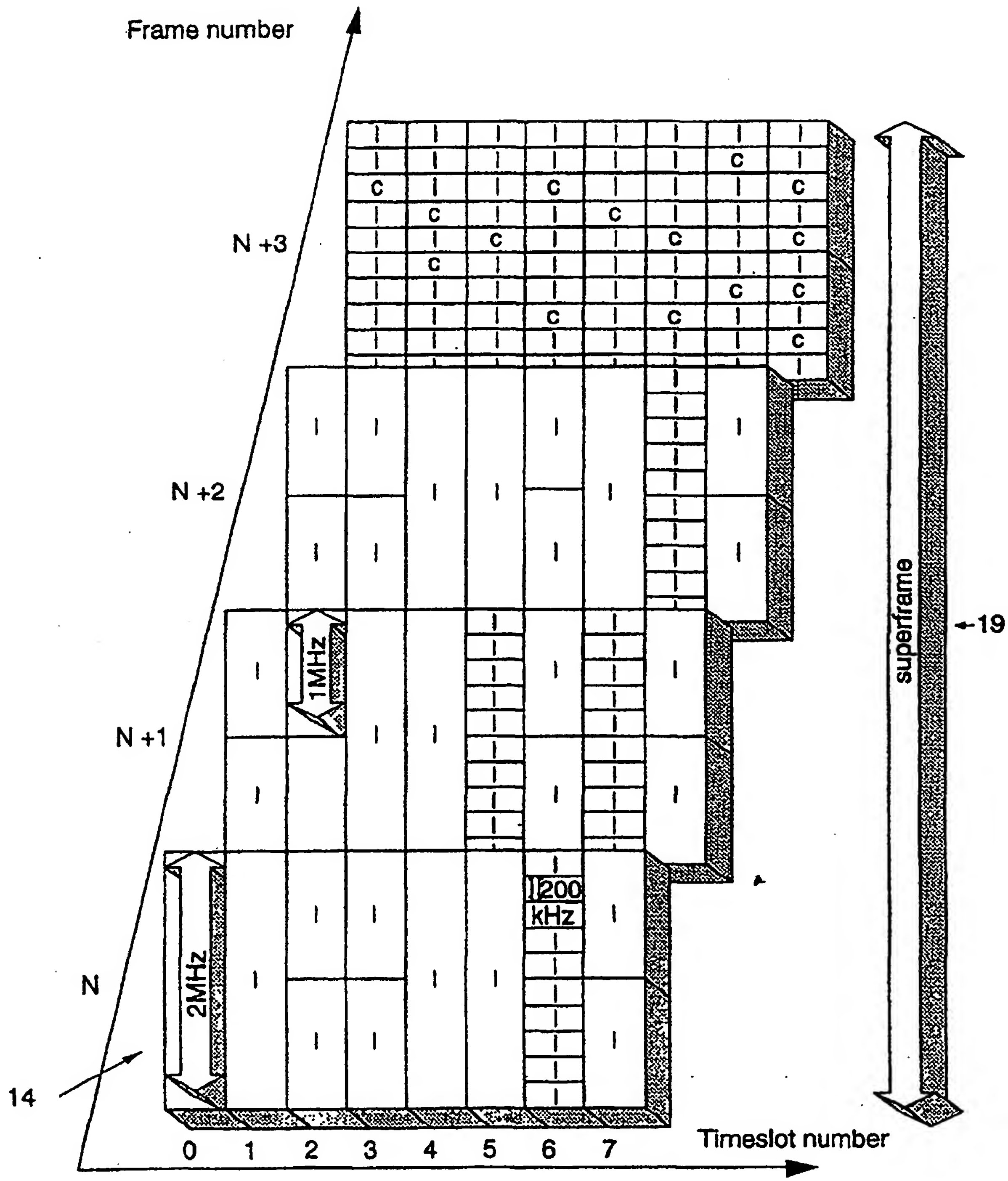

Frame number
N +3
N +2
N +1
N
14
2MHz
1MHz
200 kHz
superframe
19
0 1 2 3 4 5 6 7
Timeslot number

Fig.3

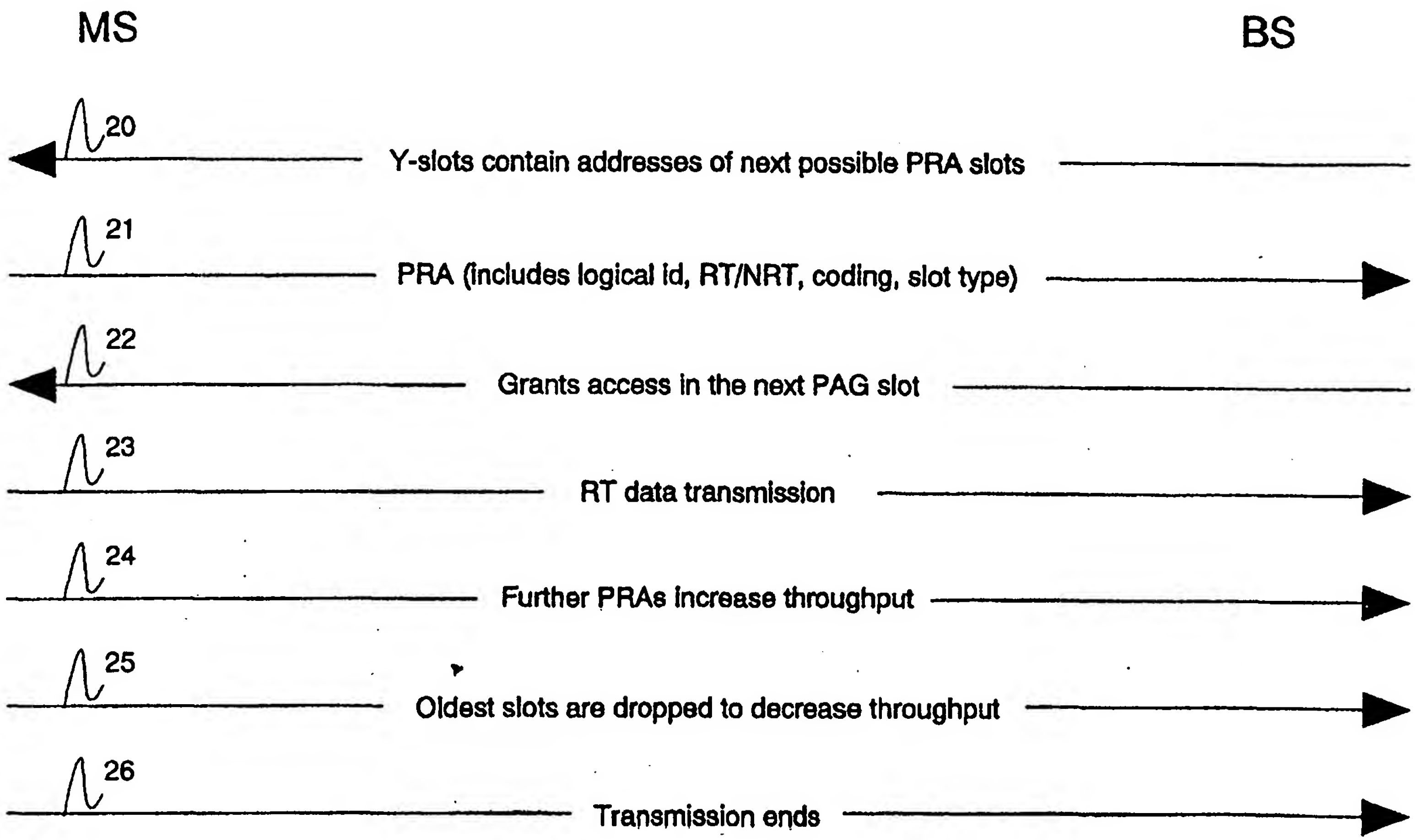

MS
BS
20
Y-slots contain addresses of next possible PRA slots
21
PRA (includes logical id, RT/NRT, coding, slot type)
22
Grants access in the next PAG slot
23
RT data transmission
24
Further PRAs increase throughput
25
Oldest slots are dropped to decrease throughput
26
Transmission ends

Fig. 4a

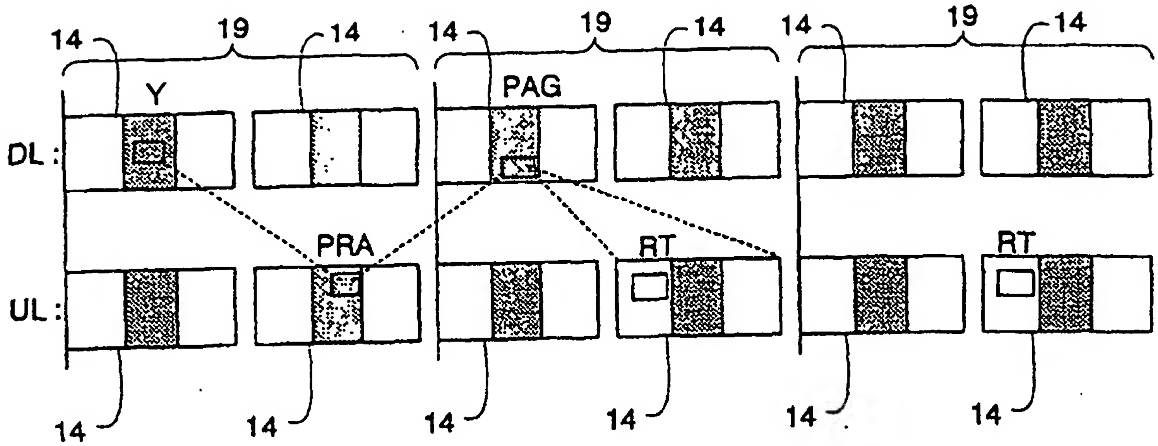

14
19
14
14
19
14
14
19
14
Y
PAG
DL :
PRA
RT
RT
UL :
14
14
14
14
14
14

Fig. 4b

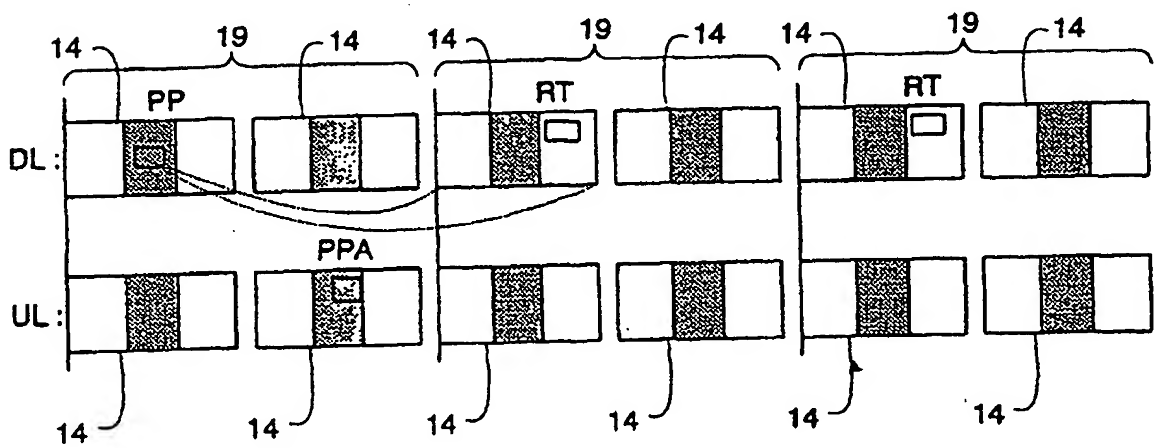

14
19
14
14
19
14
14
19
14
PP
RT
RT
DL :
PPA
UL :
14
14
14
14
14
14

Fig. 5b

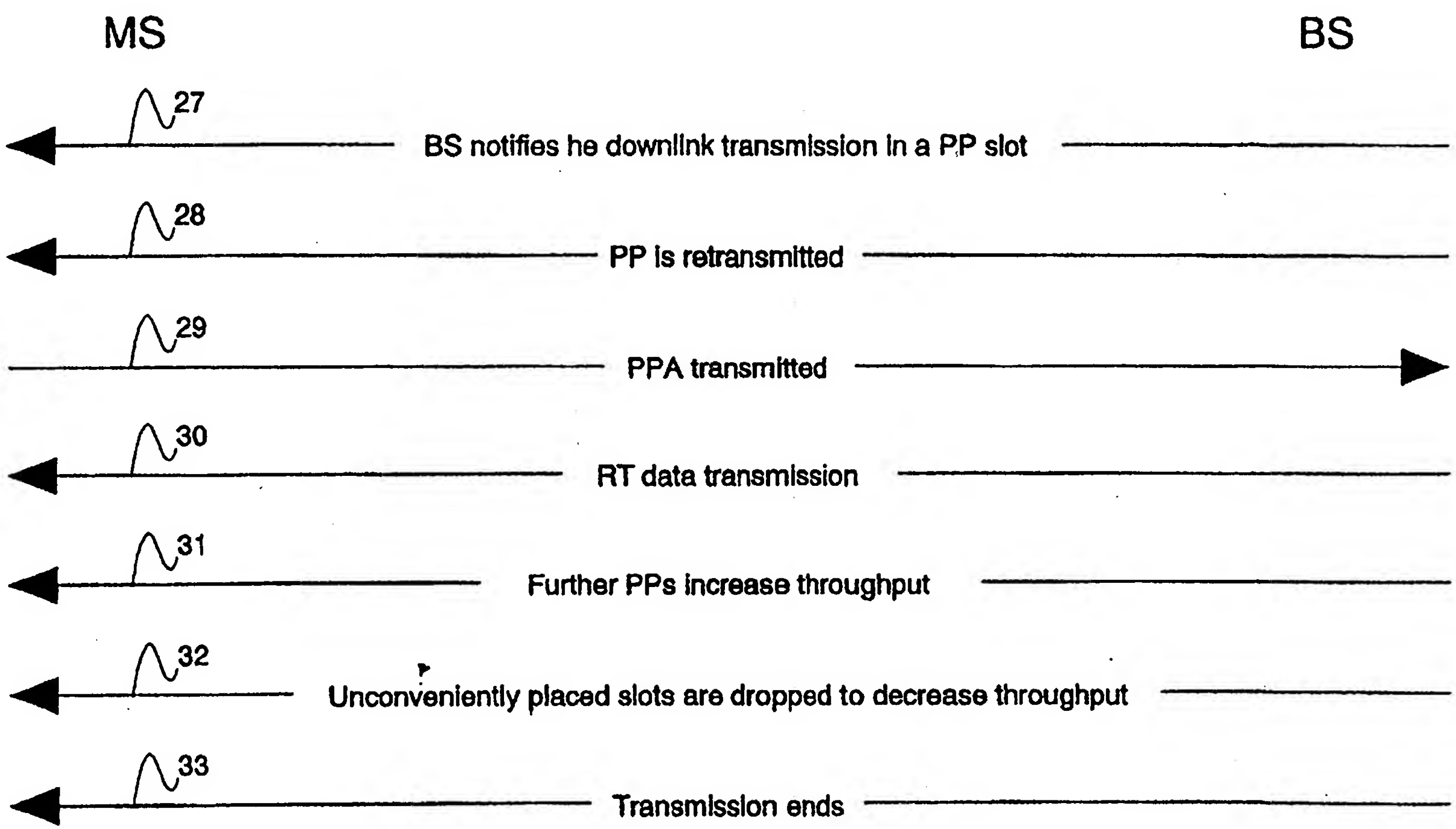

MS
BS
27
BS notifies he downlink transmission in a PP slot
28
PP is retransmitted
29
PPA transmitted
30
RT data transmission
31
Further PPs increase throughput
32
Unconveniently placed slots are dropped to decrease throughput
33
Transmission ends

Fig. 5a

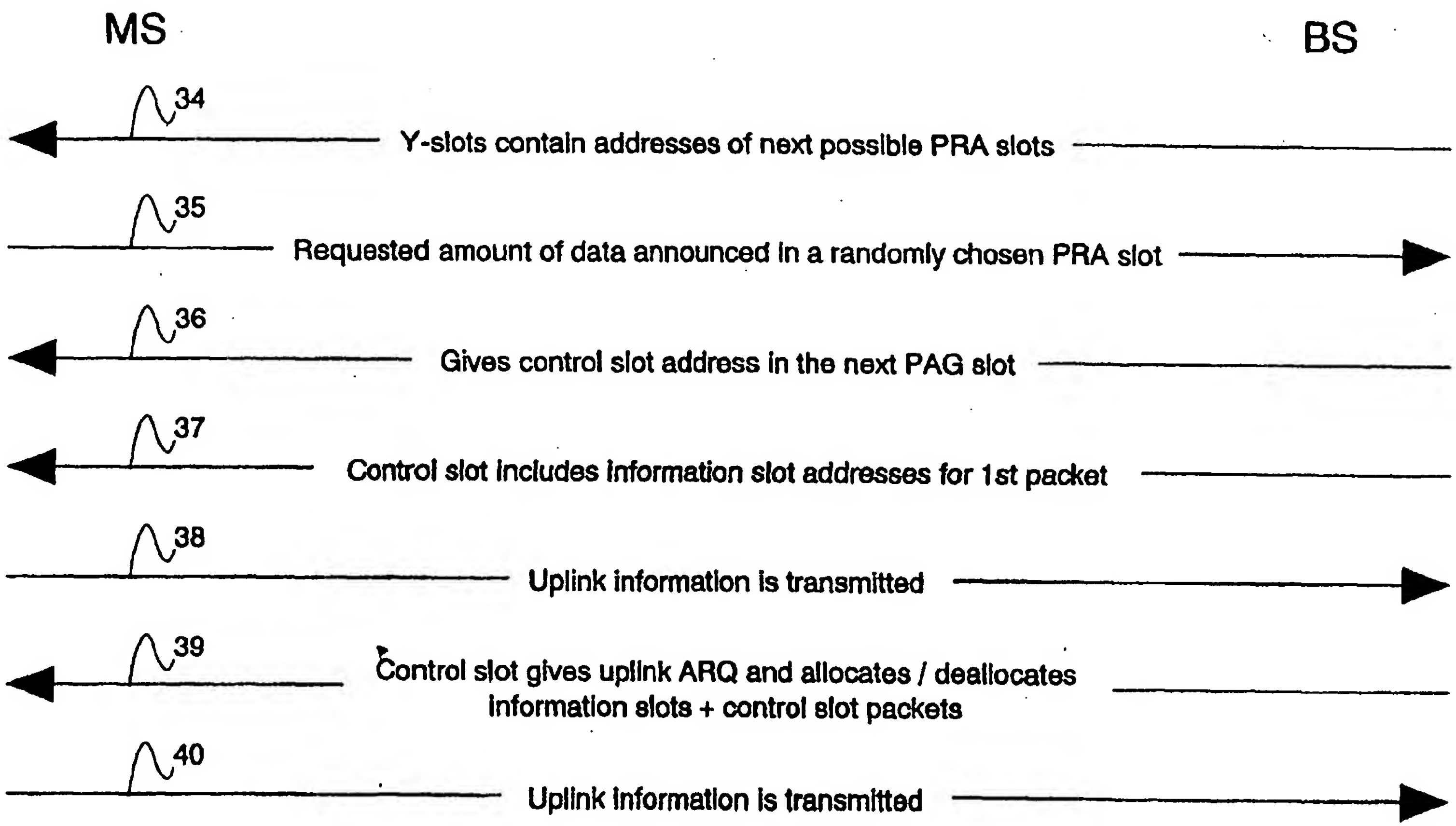

MS
BS
34
Y-slots contain addresses of next possible PRA slots
35
Requested amount of data announced in a randomly chosen PRA slot
36
Gives control slot address in the next PAG slot
37
Control slot includes information slot addresses for 1st packet
38
Uplink information is transmitted
39
Control slot gives uplink ARQ and allocates / deallocates information slots + control slot packets
40
Uplink information is transmitted

Fig. 6a

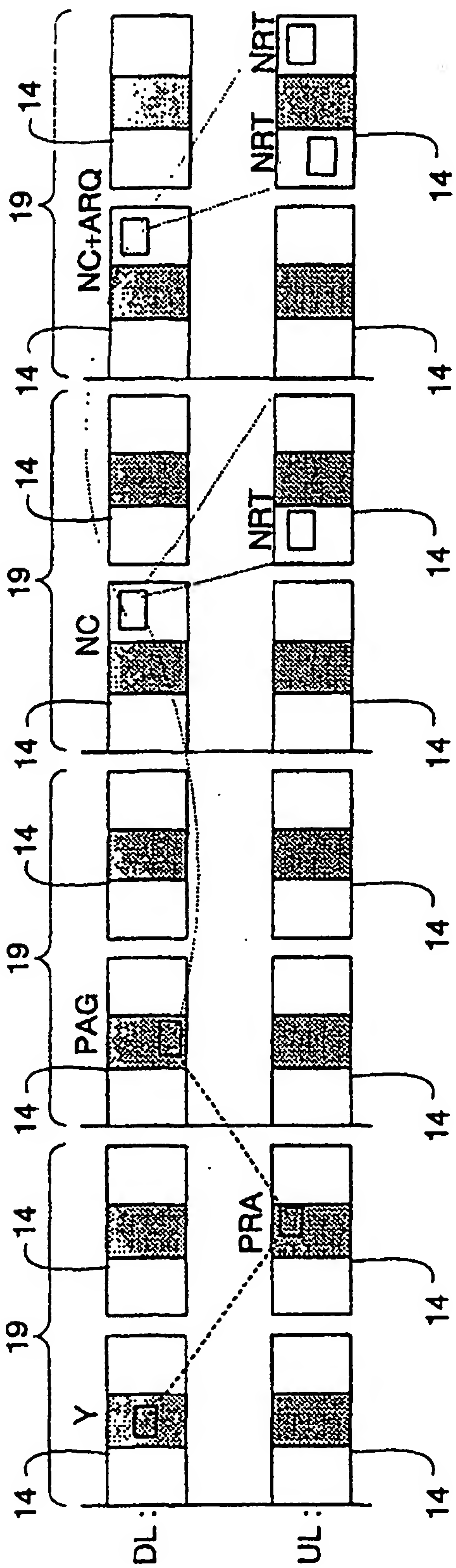


Fig. 6b

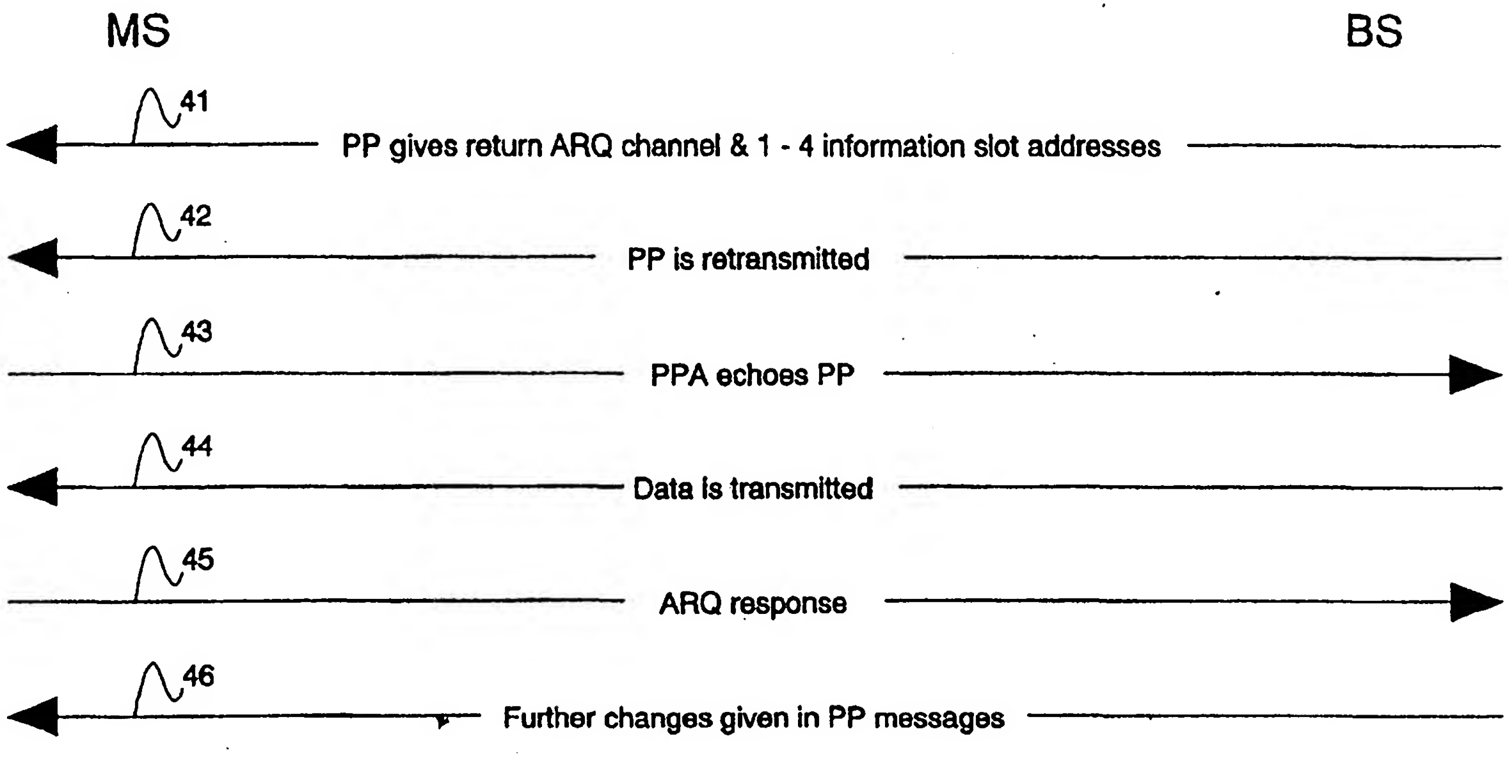

MS
BS
41
PP gives return ARQ channel & 1 - 4 information slot addresses
42
PP is retransmitted
43
PPA echoes PP
44
Data is transmitted
45
ARQ response
46
Further changes given in PP messages

Fig. 7a

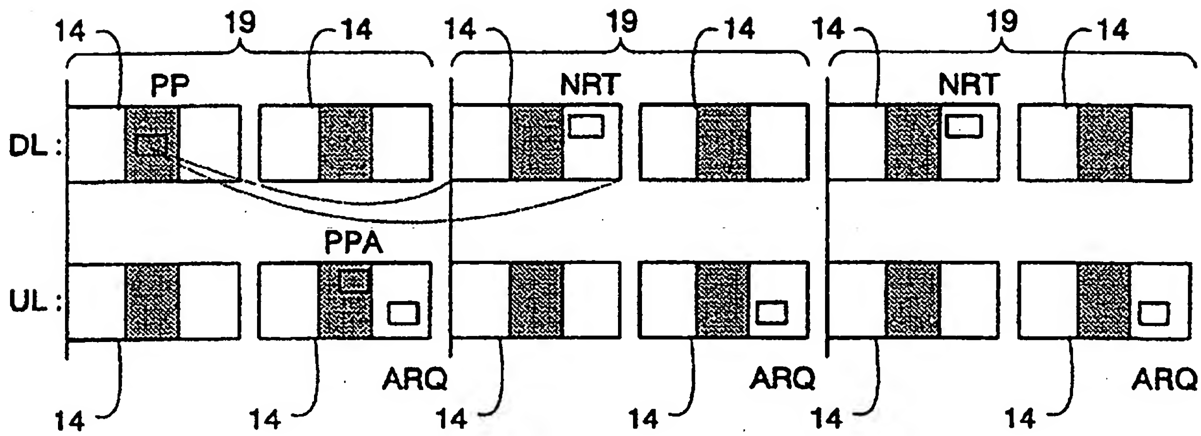

14
19
14
14
19
14
14
19
14
PP
NRT
NRT
DL :
PPA
UL :
ARQ
ARQ
ARQ
14
14
14
14
14
14

Fig. 7b

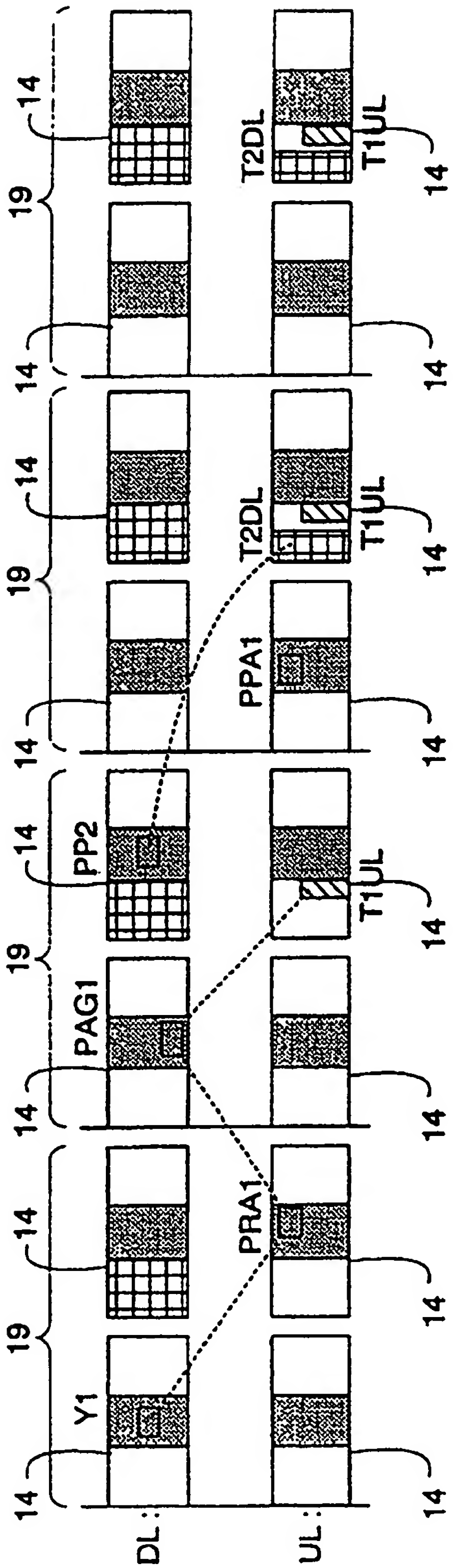


Fig. 8

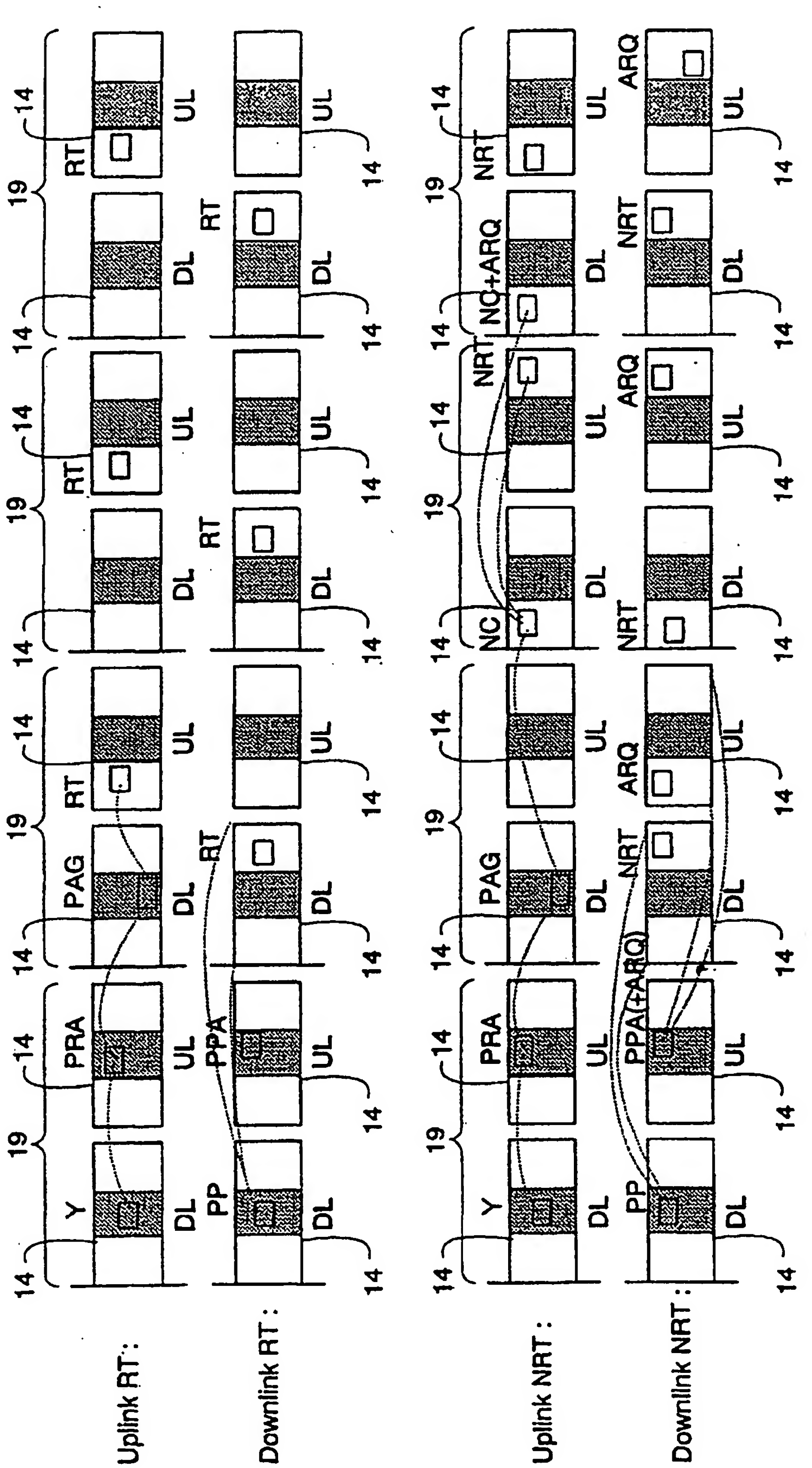

Uplink RT:
Downlink RT:
Uplink NRT:
Downlink NRT:
Y
PRA
PAG
RT
PP
PPA
NC
NC+ARQ
NRT
ARQ
PPA(+ARQ)
DL
UL
14
19

Fig. 9

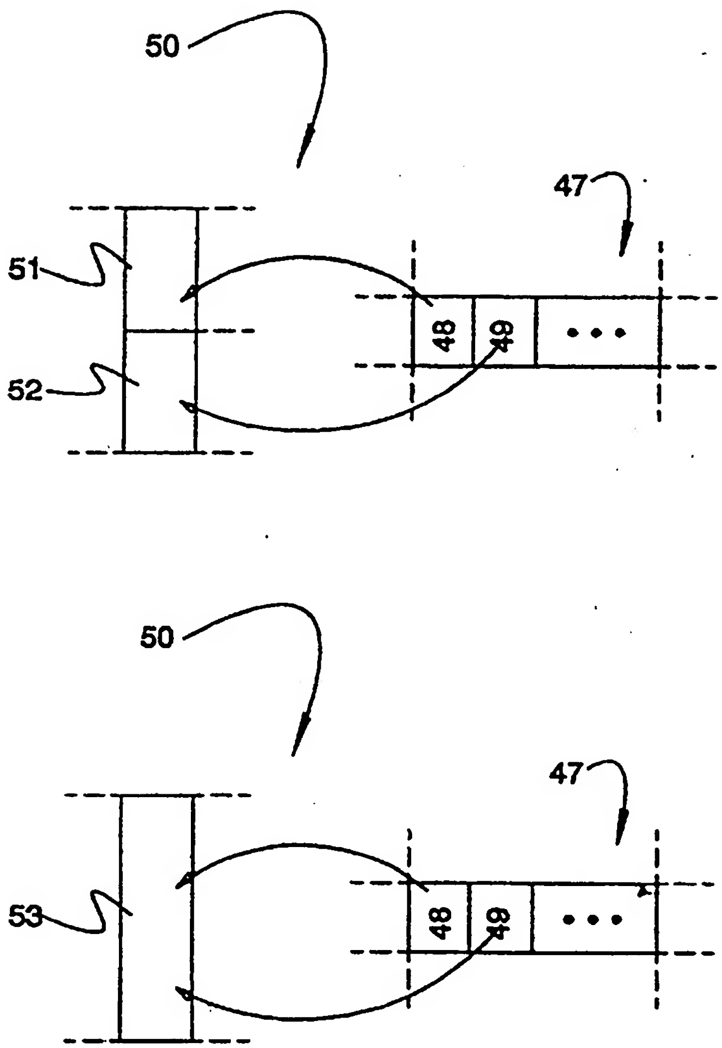
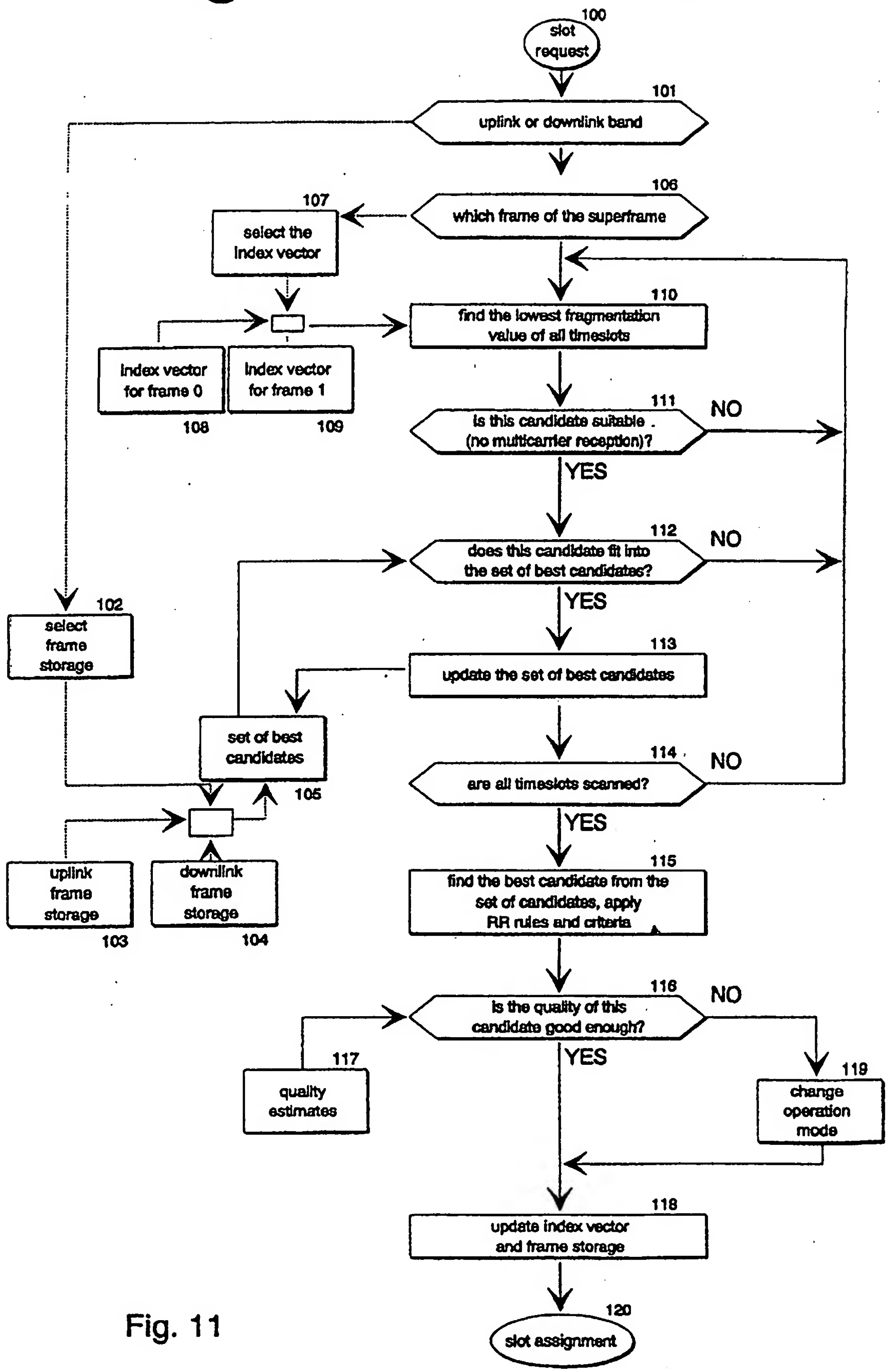


Fig. 10



100
slot request
101
uplink or downlink band
106
which frame of the superframe
107
select the index vector
index vector for frame 0
108
index vector for frame 1
109
110
find the lowest fragmentation value of all timeslots
111
is this candidate suitable (no multicarrier reception)?
NO
YES
112
does this candidate fit into the set of best candidates?
NO
YES
102
select frame storage
113
update the set of best candidates
set of best candidates
105
114
are all timeslots scanned?
NO
YES
uplink frame storage
103
downlink frame storage
104
115
find the best candidate from the set of candidates, apply RR rules and criteria
116
is the quality of this candidate good enough?
NO
YES
117
quality estimates
119
change operation mode
118
update index vector and frame storage
120
slot assignment

Fig. 11

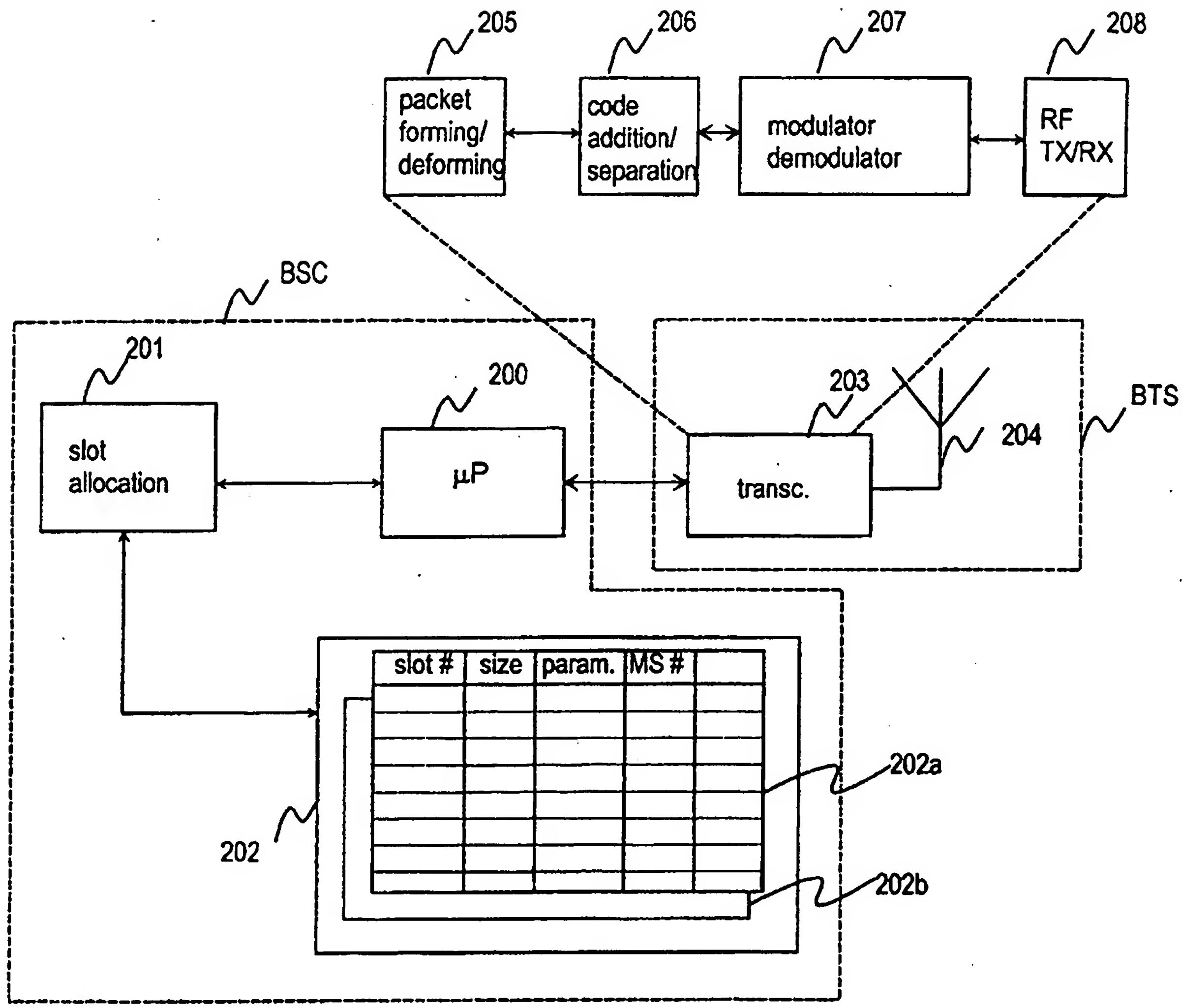

205
206
207
208
packet forming/ deforming
code addition/ separation
modulator demodulator
RF TX/RX
BSC
201
200
203
BTS
204
slot allocation
μP
transc.
slot #
size
param.
MS #
202a
202
202b

Fig. 12a

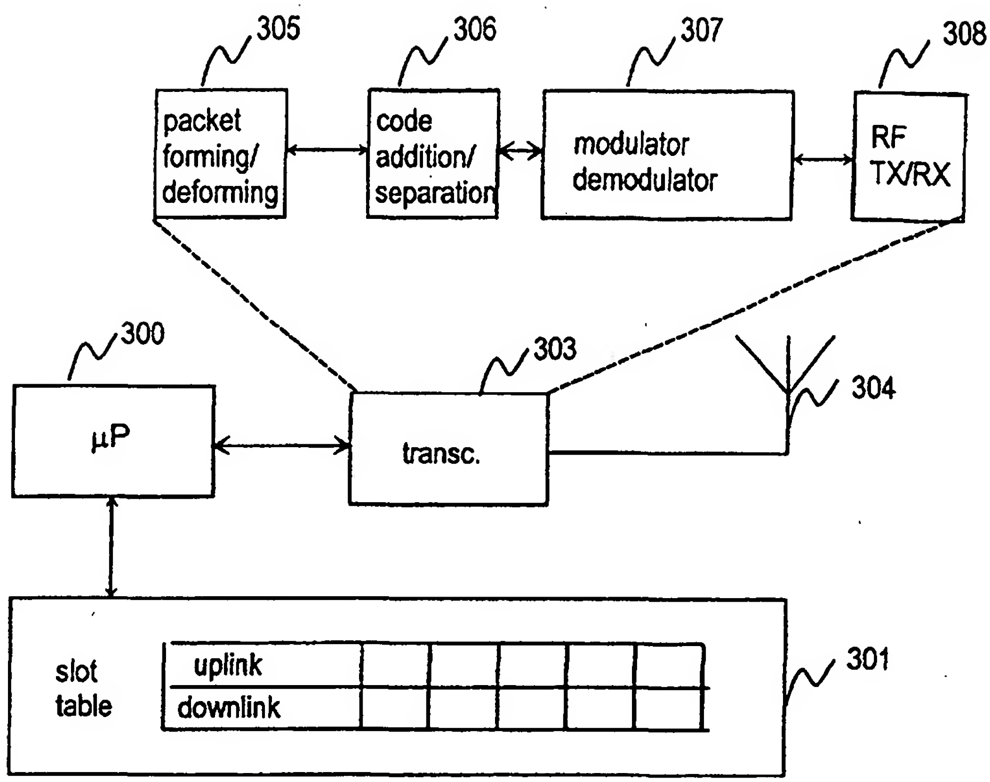

305
306
307
308
packet forming/ deforming
code addition/ separation
modulator demodulator
RF TX/RX
300
303
304
μP
transc.
slot table
uplink
downlink
301

Fig. 12b